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ML.U. 20-7
Dept. of Northern Affairs and National Resources

The Increase of Forage Lichens and the Methods for their Regulation

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V.N. ANDREEV.

The increase of forage lichens and the methods for their regulation

Introduction

The bushy (fruticose) forage lichens, that are known as "YAGEL" (Cladonia rangiferina. Tr.), are of great importance, especially in the Far North; for they safegard the development of one of the basic branches of the northern economy -- reindeer breeding. As early as the 18th century the attention of the first Russian explorers of the North was attracted. Acad. Ivan LEPEKHIN wrote that the reindeer in winter feed upon a white, bitter moss, that grows on swamps, called "YAGOL" (Cladonia rangiferina. Tr.) (1805, page 351). Seeing that it possesses valuable properties -- a high content of carbohydrates easily assimilated by the reindeer and the fact that the former are retained or preserved for the entire duration of the long winter the fruticose lichens are the main fodder for the wild as well as the domestic reindeer. The Cladonia rangiferina comprises about 2/3 of the amount of fodder consumed by the reindeer in the course of a year on the grazing grounds. During the winter the amount of Cladonia rangiferina in the diet of the reindeer in the regions with an abundance of lichens increases to 85 - 100%. The reindeer is the only domestic animal that feeds upon Cladonia rangiferina. By means of the reindeer vast reserves or stocks of lichen-fodders that exist in nature, can be drawn into the "economic circulation or turnover" and thus be utilized in the socialist agricultural economy.

Much attention is allotted in the Soviet Union to the development of reindeer breeding in the north. It is being planned to increase the number of reindeer as well as their productivity. For this purpose a number of government measures is being enacted. The measures to improve or

strengthen the food reserves are the most important ones.

The study of the lichens that is conducted in order to facilitate the solution of the assigned task is of great interest to the national economy. Besides the importance of the lichens as feeder plants some of their fruticose forms can also be used as food and medicinal plants or herbs; this has been the practice of the local population (SHCHEGLOV, 1828). In this respect, it is important to state that Soviet researchers have established the vitamin-potency of several species (SAVICH, 1939). The lichens can be used as a source of gelatinous substances; technological processes have also been developed for extracting alcohol and glucose from lichens (KURSANOV and DYACHKOV, 1945; DYACHKOV and KURSANOV, 1945). At the moment what is needed for the solution of practical questions has been studied exhaustively, namely: the specific composition of the lichens (reindeer mosses. Tr.), the chemical composition and feeding value of certain species and methods were developed to establish the reserves of lichen-fodders. The biology of the growth and development of the fruticose lichens have been studied the least. The questions at the moment, are of utmost importance in developing a system for the proper utilization of the reindeer growing grounds and the increase of their productivity.

It must also be taken into account that the lichens play a prominent rôle in the formation of a vegetative cover. Their importance is especially great during the first stages of populating new territories in the mountains and in the Arctic with vegetation. K.A. TIMIRIAZEV called the

lichens "the mighty pioneer of the vegetative world" (1948, page 22). The fruticose lichens, primarily Cladonia rangiferina, are part of the most important formations of the vegetative cover of the Far North and in some of them they play a dominant rôle. The opinion of the most prominent Russian lichenologist A.A. ELENKIN, namely, that in the Arctic region the fruticose lichens prevail upon the foliaceous lichens (1909, page 7) is beeing confirmed at present by numerous materials on the quantitative survey.

In the PECHORA area of the North, according to our researches, the vegetative covers with a considerable participation of the forage fruticose lichens (the genuine Cladonia rangiferina comprise more than 15% of the cover) occupy the following - in % - of the general area:

In the subzone of the northern taiga	33
In the subzone of the forests near the tundra	45
In the subzone of the tundra-sparse forests	74
In the subzone of the southern tundra	54
In the subzone of the northern tundra	52
In the subzone of the Arctic tundra	18

The data on the growth of the fruticose lichens make it possible to understand a number of the peculiarities of the plant communities of the tundra and of the northern forests and of the regularities of their distribution or occurrence. Without these data it is difficult to produce a scientifically based prediction of the development of the vegetative cover and to solve the problems that are related to its transformation.

Until recently there existed no reliable material on the growth of the forage lichens.

S.V. KERCHELLI, an expert on northern reindeer breeding, pointed out in 1921 that there existed no established data that could be used in the restoration of reindeer moss (1921).

Contemporary literature contains contradictory information on the periods for the restoration of the reindeer moss. At times a rather wide range from 10 to 50 years is indicated (P.VLOV, 1948), there are suggestions for a 15-year period for restoration (SOCHAVA, 1933, 1934), for a 10-year period (BOGDANOVSKAYA, 1938), for a 15-20 year period (GORODKOV, 1926). At the same time experienced reindeer breeders observe that 2-3 years after the reinder moss-grazing grounds have been pastured they are fit again for pasturing.

During recent years, in connection with the development of the experimental work in the realm of the agriculture of the Far North, mass-data were obtained on the growth of the fruticose lichens, which is of interest to science and to economy. In the main these data belong to the last decade and were not embodied in the collated work by B.N. GORODKOV (1936).

This article contains some itemized results of the study on the growth or increase of the fruticose lichens and on the experiments to regulate it. This study was conducted with the participation and under the direction of the author within the system of the Scientific Research Institute for Arctic agriculture, livestock breeding and Hunting and Fishing in the expeditions of the Department of Agriculture of the R.S.F.S.R. (Russian Soviet Federated Socialist Republic) for the regulation of the distribution of lands in the territories of the Far North.

Besides the author the following participated in collecting the factual material: M.N. AVRAMCHIK (ANADYR, 1941-1943), A.V. VAGINGER (lower reaches of the PECHORA river, 1948-1949), B.M. GLINKA (in the same place, 1937-1941), G.I. KAREV (in the same place, 1950-1951), I.D. KILDYUSHEVSKI (MALY YAMAL, 1940-1944), V.A. KOVAKINA (the KOLA peninsula, 1948-1951), A.T. REUTT (the Kola

peninsula, 1948; the KUREY. river, 1949, and the CHUKOTSK national district, 1950-1951), N.I. TYUNOEV (Northern KAMCHATKA , 1948-1950). The material by the enumerated authors is kept in the Institute for Arctic (polar) agriculture, livestock industry and hunting and fishing and as well as in the Head Office for the administration of the administration of the agricultural regions of the Far North of the Department of Agriculture of RSFSR.

This work was revised by a number of outstanding specialists. The author is particularly grateful for the critical remarks and valuable practical advice by B.N. GORODKOV, V.P. SAVICH, A.I. TOLMACHEV, B.A. TIKHOMIROV, V.N. VASILYEV; F. YA. GVLCHAK, K.A. RADADIN., M.N. AVRAMCHIK and N.I. TYUNOEV.

I. The history of the problem.

Information on the growth-rate of the fruticose lichens that merit attention, was first published in world literature by G.I. TANFILYEV. After his journey in 1892 into the MALOZEMELSKAYA and TIMANSKAYA tundras G.I. TANFILYEV indicated for reindeer moss having in mind Cladonia alpestris (L) RABH, Cl. sylvatica (L.) HOFFM and Cl. rangiferina (L) WEB.) an annual increase in growth of 4-5 mm (1894, 1901). Under favorable conditions, it is observed by G.I. TANFILYEV, there is a growth-rate of 5-7 mm per annum (1911, page 34). TANFILYEV established these growth-rates on the basis of the growth observed on reindeer-moss upon which the reindeer had browsed. Furthermore, he relied upon the experience of the reindeer-herders. The data by G.I. TANFILYEV are confirmed by contemporary research.

The work of G.I. TANFILYEV was forgotten in Russian literature (ELENKIN, 1922; GORODKOV, 1936; GOLLERBAKH and ELENKIN, 1938), as well as in foreign literature (LINIO, 1897; Smith, 1921; FERE-L Lamo, 1944). Until recently one was usually referred to the experiments by KRABBE, who established for Cladonia rangiferina in western Germany (OSNABRÜK) an annual increase or growth-rate of 3-55 mm (KRABBE, 1891). However, as will be shown later, this rate was based upon insufficient observations and is not reliable.

Experimental work to establish the growth-rate of fruticose lichens on a large scale was first carried out in our country. The first researches in this direction were organized in the Soviet Far North by the PECHORA Agricultural Station in 1926 (SUCHUK, 1926), later by the Scientific Research Institute for reindeer breeding in 1930 in the center of the KOLA peninsula on the PONOY river (SALEKIN, 1937), in 1933 in the lower reaches of the OB river near the town SALEKHARD (IOOSHINA, 1939) and in 1935 in the lower reaches of the PECHORA river near the village KHANYAGA (experiments by D.M. GLINKA).

The first experiments failed to produce positive results; for they were conducted according to the faulty method of TENGWALL who applied it in northern Sweden in 1914-1919 (TENGWALL, 1926). This method is based on the change in the height of individual specimens of lichens with regard to a number of rigid datum-marks driven into the ground alongside them. The observations by A.B. SALAMKIN, K.N. IOOSHINA and D.M. GLINKA the change in the height of the lichens with regard to the datum-marks is a result not only of the growth of the lichens, but also of their rotting away from below as well as the subsiding of the lichen-cover under the pressure (weight) of the snow in winter, the subsequent unbegging of the lichens in summer, changes in their height under the

influence of the change in the humidity of the atmosphere as well as the results from the slight fluctuations of the datum-marks themselves due to the freezing and thawing of the ground. Due to this the established growth-rates of the lichens did not dove-tail with the local conditions and in a number of cases were negative. The data on the growth of the fruticose lichens obtained by this method do not merit attention.

The growth-rates of the lichens, published prior to 1940 in the literature, on reindeer grazing grounds, were based mainly on the data by KRAUSE and on the general considerations or notions about the probable growth-rates. In the first work that dealt especially with the reindeer grazing grounds, published by B.N. GORODKOV in 1946, only the data by KRAUSE are adduced. On the basis of these general notions regarding the reduction in the growth-rate as one moves northward, mentioned in the same work, and on the basis of the information gathered on the restoration of the reindeer grasses B.N. GORODKOV later published the tentative growth-rates of the lichens in a zonal cross-section. He indicates a growth-rate of 3-5 mm for the forest and forest-tundra zone (TANFILYEV reports 4-5mm of growth for these conditions), for the southern tundra - 2-3mm, for the Arctic tundra - 1-2 mm (1934, page 54). Afterwards B.N. GORODKOV defined the data published by him, namely: For the ~~tundra zone - 4-6 mm, for the forest-tundra - 3-4 mm~~, the other rates or values remained unchanged (1935, p. 73; 1938, p. 321).

The data by B.N. GORODKOV were incorporated in the summary on the botanical geography of the U.S.S.R. as a result, as it were, "of thorough observations (TANFILOV, 1948, pp. 60-61).

For the YAMALO-NENETSK area we adopted the following annual growth-rates: For the "taiga" region -- 3 mm; for the forest-tundra and the southern tundra -- 4mm; for the Arctic tundra -- 1mm (ANDREYEV, 1934, page 128). For the Arctic "POLYMALYE" (Ural region) the following rates were reported: For the "KUSTOLESHYE" (with sparse tree-growth. Tr.) -- 4mm; for the mountain tundras -- 3mm; for the flat tundras -- 2 mm; for swamps or bogs -- 3mm (ANDREYEV, ZOLOTIN., LYUBOV, 1935, pages 231-233). A rate of 5 mm was reported for the forest-tundra of the Far East and for the tundra -- 2.5mm (GOROBKOV, 1933, p. 152). The first of these rates was regarded as exaggerated by V.N. VASILYEV (1936, p. 86).

Bearing in mind the shortcomings of the TORNALL method B.N. GOROBKOV in 1934 suggested a new method for the study of the growth-increase of the fruticose lichens, which consisted of making marks on the podetium (either with indelible ink or by strings tied around) and of measuring the distance between the marks at the time when the lichens pass through the most humid state. The method by B.N. GOROBKOV made it possible to eliminate entirely the difficulties that arise when applying the TORNALL method. Furthermore by means of it one could establish the growth-rate not only of the podetium as a whole but also of its separate parts as well as the rate of the dying off of the lower part of the podetium.

The work according to the new method at the initiative and under the direction of B.N. GOROBKOV was started in a net-work of the experimental stations of the Institute of reindeer-breeding, which later became the Scientific Research Institute for Arctic agriculture, Animal husbandry and Hunting and Fishing. At the KHARLOVK station (the POROY river) the work was carried out from 1935 to 1937 by A.D. SOLOKIN (1937), at the NARYAN-MAR (lower reaches of the PECHORA river)

station by [illegible] from 1935 to 1941, at the [illegible] station (foothills of the Arctic Ural mountains near the town [illegible]) by K.S. [illegible] from 1934 till 1937 (1939) and at the [illegible] station (on the [illegible] river, in the basin of the [illegible] river) by [illegible] from 1941 to 1943.

The results of this work could not be utilized by B.N. [illegible] in the carefully compiled summary on the increase of the lichens, which was published in 1936.

Some data that resulted from the work carried out were published later by us ([illegible], 1940).

[illegible] suggested in 1937 an entirely new method for the study of the increase of the fruticose lichens. This method is based upon his discovery of a regular annual ramification or branching of the podetium. [illegible] did not have experimental data at his disposal, which would prove directly that every year there occurs one ramification of the podetium; but the indirect data adduced by him are rather convincing. If we are to proceed from the admission that the podetium grows a branch every year then -- this is inevitable -- the statement by [illegible] must be accepted: "The growth-increase of a 'bush' of reindeer moss in height during the interval of time between the two successive branches equals the sum of the linear[1] growth of all the 'joints' participating in the growth during that same period of time. It is easy to establish that this sum equals exactly the mean length of one joint, which already has ceased to grow". (1937, page 40). When comparing the growth-increase of

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[1] A joint in Cladonias are the section of the main stem of the podetium enclosed between the lateral branches. (Malechin, 1937) (See drawing 1).

Discoids elpeetris, which was established by the "mark"-method (The E.S. [illegible] method), with the average length of the joints that had stopped to grow, [illegible] obtained approximate values. In the event that the branching would not occur every year, but, for instance, every other year, then the size of the annual increase would be twice as small as the length of the joint that had ceased to grow. If the branching occurred more frequently than once a year, for instance, twice a year, then the size of the annual growth-increase would be twice as large as the length of the joint. Seeing that the experimental data do not disclose such discrepancies, it must be admitted, that the primary Discoidea branches only once a year. [illegible] established that from the top down the length of the pedicum the size of the joints increases gradually, but at a slower rate of 2-4 as from the top grows more or less uniform. The mean length of the joints, that have ceased to grow and have left the growth-zone, corresponds to the value or size of the mean increase. Thus in order to establish the increase of the Discoidea [illegible] suggested to measure the length of the joints in the lower part of the pedicum that had stopped to grow. (1937).

[illegible], on the basis of the work carried out in the foothills of the Swiss Jura mountains (1937) confirmed the conclusion of [illegible] about the increase of the Pleistocene once a year by a similar method, i.e. by a comparison of the rate of the increase by the "mark"-method with the length of the joints. However, in distinction from [illegible], she assumes that the increase of the Pleistocene does not equal the length of the joints that have ceased to grow, but equals the mean length of the joints of the entire pedicum, including also the growth-zone with the small not yet developed joints. [illegible] writes: "If in one year there appears one

joint then the age of the thallus equals the number of its joints. By dividing the height of the thallus by its age we get the annual growth-increase of the thallus (ibid., page 16). We will mention that IGOSHINA took the entire podetium together with the dead base.

In rejecting the method of SALAZKIN the following values are adduced by IGOSHINA: In Cladonia rangiferina the length of a mature joint equals 4.7 mm, of a medium or middle -- 3.5 mm, in Cl. alpestris correspondingly -- 3.3 and 2.5, in Cl. sylvatica -- 3.7 and 2.8. The SALAZKIN method, in the opinion of IGOSHINA can not be applied in a practical sense; for it produces exaggerated values.

In 1940 -- for the work on the "supporting" net-work of the Institute for Arctic Agriculture, Animal Husbandry and Hunting and Fishing and for the expeditions for establishing the territories for reindeer breeding -- we devised a method for determining the growth-increase of reindeer-moss. This method was confirmed by the Learned Council of the Institute and accepted by the NARKOMZEM (People's Commissariat for Agriculture. Tr.) of the RSFSR in 1941. For the fruticose species of Cladonias the method provided the determination of the increase by way of establishing the length of the average or middle joint of only the living part of the podetium. We proceeded from the point that it was of practicalimportance to learn the rate of the formation of the living part of the podetium. The dying part of the podetium has no food value and is not included in the food reserves. The length of a joint that has ceased to grow characterizes the increase of a fully mature podetium when it produces not a food reserve but a lichen peat turf. For this reason the SALAZKIN method can be used for determining the rate of the accumulation of the lichen turf and can not be used in determining the rate of the formation of a food reserve.

The method by IGOSHINA characterizes the formation-rate of the entire lichen-mass of the dead as well as of the living; for this reason it can not be accepted for practical purposes. The only proper thing is the strict separation of the living part from the dead part. We recommend to determine the length of the living part when the podetium is in a state of a maximal moisture-saturation. By dividing the obtained value by the number of the joints in the living part we obtain the size of the medium or middle joint. Not till 1952 this method was indicated in literature (ANDREEV, 1952).

For research on stations we suggested to use the "mark" method of V.N. GORODKOV for all lichens except the Cladonias as well as for a small number of specimens of Cladonias for the purpose of obtaining material for a comparison with the given method of the "medium or middle joint". In connection with this it was required not only to determine the size or extent of the "stretching" of the podetium but also the rate of its dying-off.

Beginning in 1940 the entire material on the increase of the reindeer moss in the Far North was collected, in the main, in keeping with our method.

II. Peculiarities of the growth of the podetium

For the work to organize the proper use and consolidation of the feed base of reindeer breeding mass-data are required on the growth-rate and the restoration of the main fouder of the reindeer, namely, reindeer moss. The latter consists primarily of Cladonia alpestris (L.) RABH., Cl. sylvatica (L.) HOFFM. and Cl. rangiferina (L.) WEB., which in the western areas of the Far North comprise 85 - 90% of the entire reindeer moss consumed by reindeer and in the eastern areas - 75 - 85%. The second place is held by Cetraria

cucullata (BELL.) ACH., which comprises from 2 - 5% in the west and up to 10-20% in the east. The third place is held by a group of species of STEREOCAULON (primary ST. tomentosum (Tr.) Th. Fr., St. paschale (L.) FR., St. alpinum LAUR.), which in the west comprises 5 - 10%, in the east 2 - 5%; in the fourth place are all the other species of the fruticose lichens which play an insignificant part in the total composition of the reindeer moss fodders.

Thus the data on the increase and restoration of the podetium of the Cladonias should be of the greatest practical value.

I. The annual formation of joints and their duration.

The fact of a regular annual branching or ramification of the podetium of the Cladonias of the Far North is sufficiently clarified at present. Besides the confirmation of this phenomenon by K.N. IGOSHINA a large amount of material was obtained by D.M. GLINKA at the NARYAN'AR reindeer breeding station by comparing the increase -by the "mark"-method- with the length of the middle or average joint. During thee 1937-1941 period GLINKA studied, by means of the "mark"-method, the growth-increase of 543 podetia and by the "middle joint" method the growth-increase of 895 podetia, that were taken from the same places. In the mean the annual increase of Cl. alpestris, Cl. sylvatica and Cl. rangiferina, according to the "middle joint" method, amounted to 5.2 mm in the brush-lichen tundra and to 9.3 mm in the pine-lichen forest and, according to the "mark"-method, it amounted to 4.9 mm and 9.4 mm in the same places.

GLINKA, in his report on the work carried out (1941), comes to the conclusion that the "indications obtained by both methods for determining the increase of reindeer moss are very similar. This, no doubt, speaks of the fact that in the case

of the reindeer mosses used in the experiment these is formed only one "joint" (KOLENO-Russian. Tr.) every year".

We selected three podetia in the surrounding area of NARYAN-MAR, which were marked. They belonged to Cl. rangiferina. These podetia during 1942-1944 were examined every year in May or June. In August or in the early part of September a drawing was made of the terminal branches and the length of each joint was measured. As a result it was established, without a doubt, that during the observation period the branching of the main stem of the podetium occurred only at the top and only once a year. The youngest top joint appears in summer, in the latter part of August it is represented by a "small horn" the length of which usually does not exceed 0.2 - 0.4 mm and towards June of the next year it reaches a length of 0.6 - 0.7 and at times of 1 mm.

Thus all the data at our disposal confirm the phenomenon of a single annual branching of the podetium. If there occurs, at one time or another, a delay in the branching or an acceleration in the branching it should, so it seems, be regarded as the result of the effect of special factors, a deviation from the regular course of things.

As was already known earlier the sizes of the joints increase from the top downward, but only to a certain limit from which the size of the joints becomes more uniform. A.S. SALMIN calls the upper part of the podetium with the enlarging joints the growth-zone of the podetium (1937, page 49), in which the stem of the podetium has a more or less regular cylindrical form. Further down the stem is flattened or compressed, its walls grow thinner and the central cavity expands. It is characteristic that the gonidial layer can be observed only on slices from the growth-zone, further down the cells of algae are lacking or occur singly. Experiments

with the rooting of the "fragments" of fruticose lichens that were carried out by us in 1929 - 1930 on the ARKHANGELSK experimental marshy field, by SALAZKIN in 1934-1937 at the Murmansk reindeer breeding station, by K.N. IGOSHINA in 1933-1937 at the YAMALSKAYA station (1939), by A.V. VAZINGER-ALEKTOROVA and G.I. KAREV in 1947-1951 at the NARYAN-MAR reindeer breeding station, showed that only "fragments" from the upper growing part of the podetium take root, whereas "fragments" from the lower part die in 1-2 years and do not possess the capacity to take root. In this respect the data by the old or former authors, who asserted that reindeer moss can be renewed from "every insignificant scrap" (TANFILYEV, 1894) page 24) demand definition.

With regard to the chemical composition the lower part of the podetium differs from the upper growing part by a decrease of the protein content (from 2.4% to 1.7%), by an increase of cellulose (from 32% to 40%) and of ashes (from 1.5% to 2.0%) (AKSENOVA, 1937).

In most cases the part of the podetium in which the size of the joints becomes constant, differs with regard to color from the Upper part of the podetium. This can be seen very clearly in the case of Cl. rangiferina in which the lower part of the podetium grows considerably darker. It passes gradually into the black turf base of the podetium.

Thus the morphological, anatomical, biochemical and physiological data with one voice point to the fact that the lower part of the podetium in which the length of the joints becomes constant is either completely or partly dead. In view of this there is no need to introduce such new terms as "a growth-zone", "a growing zone", "the limit of the big growth" that occur in the literature published. It is quite sufficient to distinguish between the living and the dead parts of the podetium (including the dying part). The first part

of the podetium for its full length is characterized by a growth that gradually dies down towards the base; the second part - by the decomposition of the organic matter which is intensified from the top downward (drawing 1).

A.A. ELENKIN voiced the opinion that in the "necral zone" of the podetium the preservation of a fungous component, that continues to exist at the cost of the upper part of the podetium which is equipped with gonidia, is possible (1911, page 480). With respect to the entire "necral zone" this suggestion can not be accepted; for there is no doubt that the fungous component in the base of the podetium dies off completely and the podetium itself is turned into a dead peaty mass. In the upper part of the"necral zone" the fungous component can exist for a certain time, it survives the algs for a little while. This dying part of the podetium is gradually fused with the dead part; they are brought together by the absence of growth-processes.

When bearing in mind the annual branching of the tops of the podetium it must be admitted that the age of the joints of the podetium increases the further away they are from the top. The youngest joints are in the upper part of the podetium, the oldest are in the base. If one considers the regularity of the branching and the formation of one joint every year then one must admit that each joint located further down is one year older than the contiguous upper joint or the joint above it. This makes it possible to determine -by the number of the joints- the age of the podetium and by the length of the joints one can establish the growth-rate of the podetium during the various periods of its existence. The size of the joints from the top or tip of the podetium towards its base reflects the growth-increase from the first year of its existence. It is not hard to establish that the length of the first joint from the top corresponds to the

increase of the first year of existence, the length of the second joint from the top corresponds to the increase of the second year of existence, of the third joint - to the third year, and so forth. The "scheme" of the branching of a fruticose podetium of Cladonias is shown in picture 2. Actually if during the first year of the development of the podetium only one joint is formed then its length corresponds also to the growth-increase for this year (K^1). A new joint is formed during the second year and the joint of the previous years, which has become the second joint from the top due to the intercalary growth, peculiar to the lichens, stretches out. The length of the new joint, which is now the first from the top, if the external conditions for the existence of lichens remain unaltered, is about the length of last year's joint, which last year was the first from the top. The growth-increase during the second year of existence was thus distributed between the two joints. At its cost a complete new top joint was formed and the second joint from the top was stretched out. The length of the second joint from the top is, therefore, the result of a two-year growth: In the first year it grew the length of the first joint, during the second year it increased in length by the distance that corresponds to the difference between the length of the second and the first joints. This shows that the length of the second joint from the top corresponds to the size or magnitude of the growth-increase of the podetium during the second year of its existence ($K^1 + (K^2 - K^1) = K^2$.

Drawing 1 Podetia of Cladonia sylvatica. On the left from the tundra zone (upper reaches of the LAYA river in the BOLSHEZEMELSKAYA tundra), on the right from the "taiga" zone (the TSILMA river in the KOMI A.S.S.R.). The dark dead bases of the podetia can be seen. (Nat. size. Drawn by R.M. ALEKSANDROVA). Drawing 2. Scheme of branching of the fruticose podetia of Cladonias.

K^1, K^2, K^3. . . . . K^{10}-joints of the living part of the podetium.

The growth-increase of the third year of the life of the podetium is distributed between three joints: at its cost an entirely new -the first from the top- joint is formed and the second and third are stretched out. The length of the lower or bottom joint that has become the third from the top is composed of the length of the second joint (i.e. it equals - in length- the first joint and the addition to the second) and the lengthening of the third, i.e. the length of the third joint from the top corresponds to the growth-increase during the third year of the life of the podetium ($K^1 + (K^2 - K^1) + (K^3 - K^2) = K^3$) and so forth.

Measuring the length of individual joints made it possible to establish the magnitude of the growth-increase of the podetium over the years. The first measurements were made by IGOSHINA (1939, pp. 10-11). However, the small amount of material (19 specimens) and the failure to indicate the border line between the living and dead parts of the podetium made it impossible to reach any conclusions. Below are the data from the mass-measurements of the samples from the Murmansk region (pine forests to the north of the PONOY river) carried out by us, from the YAMAL forest-tundra (sparse tree-growth on the KHETTA river, a tributary of the NADYM river), carried out by I.D. KILDYUSHEVSKI, and from the basin of the BUREYA river (larch-covered slopes on the URGA river), carried out under the direction of A.T. REUTT (table 1).

Table 1.

Length of joints in the living parts of the podetia in Cladonia species.

1. Nos. of the joints from the top down. 2 - Murmansk region. 3 - YAMAL peninsula. 4 - YAMAL peninsula. 5 - Basin of the BUREYA river. 6 - YAMAL peninsula. 7 - Basin of the BUREYA river.

a - in mm. b - in %.

I. Length of the living part of the podetium. II - Number of measured specimens.

The length of several joints in the upper part of the dead part of the podetium, with a few deviations, equals the length of the last joint in the base of the living part, but lower, under the effect of the destruction of the organic substance, it is considerably shortened.

The adduced data indicate that the life of the separate joints of the podetium in the plants studied, in the mean, lasts from 9 - 13 years, that every joint, that after appearing in the upper part of the podetium, gradually stretches and then, after passing or reaching a certain limit, begins to die off. The rate or pace of the stretching of every joint for the duration of its existence is at first accelerated, and, after having reached a maximum or climax, begins to slaken (Drawing 3).

The stoppage of growth means the beginning of dying off, the passing of the joint into the half-dead or dead part of the podetium.

The dying of the joints that have attained a maximal size, is confirmed by direct observations. During 4 years of watching -at the YAMAL reindeer breeding station- 863 podetia it was established by I.D. KILDYUSHEVSKI by the "mark" method that in the case of Cladonia alpestris, if the mean annual growth-increase amounted to 5.6 mm, the dying off comprised 5.0 mm; in Cl. sylvatica, at 5.9 mm of a growth-increase, 5.7 mm died off; in Cl. rangiferina, at 6.5 mm of growth-increase, 4.1 mm died off, in Cetraria islandica, at 3.7 mm of growth-increase, 3.7 mm died off. The author comes to the conclusion that "the growth-increase is fully absorbed by the dying off of the lower part of the thallus, if the lichens are old".

Drawing 1. Annual growth-increase of a joint of a podetium from the moment of its appearance till the dying off (Cladonia sylvatica from the forest-tundra).

I -- Annual growth-increase, in mm. 2 -- Age of joint, in years.

There are many indications in literature (TANFILYEV, 1901, 1911; SALAZKIN, RICHTER and CHERNOLUSSKI, 1932; GORODKOV, 1933; VASILYEV, 1936 and others) regarding the cessation of the accumulation of the living mass of the lichens in old reindeer moss stands due to the decomposition of the podetia at the bottom.

We observed -by means of the above-mentioned specimens of Cl. rangiferina- in the NARYAN-MAR area the annual dying off of the bottom joint of the podetium. In connection with this -by means of external marks- the dying off was established in spring. The length of the living part of the podetium, passing through negligible seasonal fluctuations(being enlarged during the summer period by the length of the largest joint and diminished or shrink during the winter period to the same extent), in the mean remained unaltered.

The decomposition of the base of the podetium of Cladonias begins at a certain age, after they have reached a certain height. In the tundras, in the reindeer breeding area, young lichens are seldom observed. One encounters usually old lichens that are producing new growth after the reindeer had fed upon them. Only on burns, where a new vegetation is formed, one can encounter new lichen-covers, which consist of podetia that lack a dead base.

2. Periods in the life of a podetium.

The above compels one to admit that the growth of the podetium of Cladonias during its life-time passes through a number of changes, that are common to all species studied and observed under various living conditions. This provides a reason to distinguish several periods in the life of a podetium.

During the first period the entire growth-increase is

used for building the living or active part of the podetium. The latter increases continuously, the rate of its growth is accelerated every year. On the basis of the material collected on the three main fodder species of Cladonia it can be assumed that in the mean this period which is called by us the period of the accumulation of growth-increase or of the formation of the podetium, lasts, in the mean, about 10 years, with fluctuations, depending upon the species of the lichen and the living conditions, from 5 to 25 years. The growth-rate of the podetium of Cladonia with a ten-year growth accumulation period is characterized by the following values (the mean from 1000 specimens) (Table 2).

There are indirect indications in the work by B.N. GORODKOV regarding the duration of this period in the life of a podetium. He observed that the decomposition of the lichens from the bottom need not be considered "in the case of very young tussocks (3-5 years)" (1936, page 89).

The second period, which is called by us the period of the renewal of the podetium, is characterized by a cessation of the lengthening of the living part of the podetium and the appearance of the dead or decomposed base of the podetium. The growth of the podetium does not stop during this period. On the contrary, each year the growth takes place at a faster rate than that reached at the end of the preceding year. However, the annual decomposition of the lower or bottom joint fully absorbs the increase or enlargement of the podetium acquired during a year as a result of the intercalary growth of its living part.

Actually, the length of the bottom joint corresponds exactly to the annual increase of the podetium during this period, A.S. SALAZKIN, who, on this basis, offered his method for establishing the linear growth-increase of the Cladonias, drew attention to it.

One must also point out the intensity of the growth in the various parts of the podetium. In literature it was stated that the growth of the podetium is observed only in its upper part for no more than 3-4 cm from the top and that the most intensive growth takes place at a distance of about 2 cm from the top (SHLAKOV, 1957).

Table 2.

Growth-rate of the podetium of the Cladonias (mean values for Cladonia alpestris, Cl. sylvatica and Cl. rangiferina in the Y.M.L forest-tundra during the period of the growth-accumulation).

A - Size of increase. B - Height of podetium.
1 - Years of existence. 2 - in mm. 3 - in % from the increase at the end of the period. 4 - in mm. 5 - in % from the height at the end of the period.

The distribution of the annual increase along the length of the podetium during the second year of its existence, i.e. the stretching of individual sections of the living part of a mature podetium is depicted by Drawing 4. The most intensive stretching or lengthening occurs in the upper or top centimeter of the podetium, where the 4-5 upper joints are concentrated. The increase dies down gradually towards the base of the podetium. The distribution of the growth-increase over the length of the podetium provides no reason to set apart -in its living part- any separate "growth-zones" as some authors tried to do. We are dealing with a living organism in which the intensity of the vital process dies down gradually in the course of time. Only a change in the living conditions can introduce changes into this process and disturb the picture usually observed.

The duration of the renewal period of the podetium, under natural conditions, can be rather long. We observed on the Y.M.L peninsula (near lake Y.MUTO in the subzone of the forest tundra) covers of Cl. alpestris the dead or decomposed part of

the podetia of which could be traced to a depth of 30 cm in the amassed lichen-peat, which with a mean growth-rate -in the given life-period- of 3.0-3.5 mm annually, points (seeing that the deformation of the dead podetium is not exactly known) to a duration of this period of approximately 100 years. In the basin of the KHLOUTTEY river on the HOLY TOTAL peninsula we discovered covers of Cl. sylvatica and Cl. rangiferina that had a dead part of the podetia of up to 45 cm in length (with an annual growth rate of 4-4.5 mm).

The period of the renewal of the podetium is replaced by the period of the dying of the podetium during which the dying off takes place at a faster rate than that of the current growth-increase. In the final end the podetium can perish altogether.

In old reindeer moss stands one observes frequently a considerable shrinkage or contraction of the living part of the podetia in comparison with the younger reindeer moss stands that grow under similar conditions. In the further course of the 'aging' of the cover one can observe all the transitions from the podetia with a shrunk living part to those that had died off completely.

The suggestion by WAINIO, (1897) of a lifespan for Cladonia rangiferina of 200-300 years under natural conditions seems rather unlikely to us. In the covers a hundred years old examined by us a considerable part of the plants was in the dying period of the podetia and some had already died off completely. Growing 4. The annual growth-increase of the individual parts of the podetium of the Cladonias in mm by centimeter-long sections from the top.

An accumulation of the dead lichen mass, which forms a white peat or turf occasions the 'swamping' of the soil, which intensifies the development of hygrophytic hepatical and

moss. As a result the lichen-community is replaced by a moss community. Even when taking into account the slow rate of the "self-development" of the plant associations of the tundra one cannot admit that a community existed without changes for 200-300 years. Drawing 5 presents a chart of the growth-increase during various periods of the existence of the podetium by the example of Cladonia sylvatica from the [illegible] forest-tundra.

The examined periods in the life of the podetium were traced only in the case of plants of a vegetative propagation. The formation of the fruiting organs could introduce essential changes into the duration of the various periods and into the growth-rates. However, this problem has not been studied at all, seeing that the fruticose Cladonias in the tundra zone fairly seldom resort to "sexual" propagation. This was pointed out by N. I. Nannfeldt (1886-1887), Almquist (1887) as well as, with some reservations concerning some species, by A. A. Elenkin (1909). The rarely encountered fruit-bearing podetia are always in the second period of existence - in the period of the renewal of the podetium.

A change in the metabolism is the cause for the transition from one period into another in the life of fruticose lichens. It is known that the lichens are a complex organism with a metabolism of a two-fold type: an autotrophic type, inherent in algae and a heterotrophic type peculiar to a fungus. Under the effect of external factors the symbiotic relations between the fungus and the algae change; this leads to essential changes in the metabolism. The suppression of the vital activity of the algae weakens the autotrophic feeding of the lichen, stops its growth and, eventually, causes it to perish. There exist several theories regarding the cause for the dying off of the lower part of the podetium. A.A. GRIGORYEV observes that as the lichen grows and the lichen-cover spreads the access of the

light to the base of the podetium becomes more difficult or restricted. As a result of this the alga perishes and subsequently also the fungus (1946). It must be admitted that this cause alone could hardly bring about the death of the alga. On the one hand, this will be seen below, the lichens develop better under conditions of a diffused and somewhat weakened light (tests by KOVALKINA). On the other hand, the dying off of the old parts of the thallus of the lichens occurs without any lessening in the intensity of the light. This is observed in a number of foliate lichens which have a "level" growth (VALLOT, 1896).

In the opinion of V.P. SAVICH the dying off of the lichens occurs as a result of the lowering of the vitality of the alga. In the body of the lichens the alga loses the ability for "sexual" propagation and as a result of a sexless propagation in number of generations its vitality is drastically lowered and it is gradually destroyed by the fungus. (Personal report by V.P. Savich). This rather plausible supposition should, in our opinion, be complemented by a consideration of the influence of the bacterial population in the body of the lichens. Although the opinion regarding a third component of the lichen-symbiosis in the form of azotobacter (HENKEL, 1946) is not confirmed by the research of N.A. KRASIL'NIKOV (1949), nevertheless, the question regarding the rôle of the bacteria in the life of lichens has not been sufficiently clarified. At the base of the podetium which to a lesser degree, in comparison with its upper part, is subject to desiccation there develops an abundant bacterial flora. The latter can suppress the already weakened cells of the alga.

It seems that the dying off of the lower cells occurs as a result of a complex of causes from which we one cannot exclude also the accumulation of mineral substances due to a development over many years as well as the aging of the protoplasm in the cells of the alga due to which it loses the power to absorb ferments (OPARIN, 1947).

A prolongation of the life of the cells of the algae will delay the dying off of the lower joints of the podetium. An extension of the existence of a joint even if only for 1-2 years could already bring about a noticeable increase in the feed reserves. This is one way to stimulate the growth of reindeer moss.

In nature one can observe that in some years there occurs an extension or prolongation of the life of individual joints and in others - their premature aging and dying off prior to the time that is the average for the given conditions. Damp but not overly warm weather facilitates the extension of the existence of the joints during the growing period as well as a long duration of the growing period. In the podetia that are in the second year life there occurs, due to this, a certain change in the dimensions of the living parts and in the number of joints in it. In a "good" year there occurs a lengthening of the living part because the bottom joint, which usually dies in turn, is kept alive. When the living conditions worsen the living part of the podetium contracts at the cost of the out of turn dying of the prematurely aged joints. When the former conditions are re-established then the podetium usually also restores the original length of the living part and the number of joints in it. Similar changes in the podetium are of great biological significance. The size of the living part of the podetium determines the size of the assimilating surface of the lichens and, consequently, the intensity of the metabolism and the rate of further growth. The larger podetia grow more rapidly. The length of the living part can also change depending on the increase or retardation of the annual growth. It is known, that in various years the magnitudes or extent of the growth can change 1½-2 times (NEKRASOVA, 1938; ANDREEV, 1948). However, the lengthening of the living part of the podetium, attained in this way, is usually considerably less than the result of the preservation of the bottom joint.

The self-regulation of the length of the living part of the podetium is an important method for adapting the lichens to the feeding-regime. On a favorable basis the development is faster, on an unfavorable one it is slower. This makes it possible for the lichens to endure or to survive radical fluctuations in the living conditions in various years and to develop under extreme conditions.

Together with the resistance of the lichens to frost and drought their ability to regulate or control the growth is also one of the causes for the wide-spread occurrence of lichens in the Far North and at high altitudes.

The great plasticity (elasticity) of the lichens, which is confirmed in recent days on the basis of their geographic occurrence or distribution and the origin of the area of the separate elements of the lichen-flora (OCHSNER, 1944-1946) must be connected with the above-mentioned biological peculiarities of the lichens.

3. The restoration or recovery of the podetium offer mechanical damage.

It is rather important for practical purposes to establish the rate at which mechanically damaged podetia sprout again. For the purpose of divising workable methods for using or utilizing reindeer moss grazing grounds it is necessary to know the time it takes for a full restoration or recovery of the feed reserves used for grazing.

Drawing 5. 1 - living joints of a podetium. 2 - dying and dedd part of a podetium. 3 - the years from the beginning of the development of the podetium. 4 - period of growth-accumulation. 5 - period of the renewal of the

A - Growth of separate joints and development of the podetium during its various periods of existence.

Our researches make it possible to answer the question with regard to the rate at which the podetia that had been grazed upon at various heights sprout again.

In summarizing the gathered material on this question we come to the following conclusions.

The time required for and the manner of sprouting depend on the size of the living part of the podetium that is left after browsing.

As a result of the removal of the entire living part the majority of the podetia usually dies and only in the case when the half-dead base still contained the living cells of the alga, they would give a start to a fresh podetium the formation of which begins after 2-3 years. If after grazing there remain no more than the two bottom living joints of which at least one would be perfectly intact then the recovery begins immediately by means of sprouts from the remaining base of the main stem.

In the recovery or restoration of the podetium on the preserved base there begins, as it were, the formation of a new podetium. It takes place at about the same rate as the growth of a new or young podetium during the first period of its existence. During the first year of the recovery there appears a small "horn" 1-2 mm long, the next year the "horn" grows branches and stretches to a length of 2-3 mm, the third year there appear new branches and the total length has grown to 3-5 mm, etc. At times one can observe, as it were, "two-storied" bushes of Cladonias: On the old podetium that had been eaten off there rises a new branched top. By the time, when the full recovery of the living part takes place, the remaining base of the old podetium usually dies, the new podetium from the period of the growth-accumulation passes into the period of the renewal of the podetium and the annual dying off of the bottom joint begins in it. The indications in literature regarding a four-year absence of growth in lichens after reindeer had fed upon them (ANDREEV, 1940, 1946, 1948) should be regarded as wrong; for the cessation of growth after grazing sets in only

when the entire living part has been removed or when the bottom joint alone has remained partially intact. In the other cases the recovery begins in the same year, although at first the growth-increase is very small. This was not considered, due to careless observations, by some researchers. If only the top is removed (less than ½ of the height of the podetium) one of the remaining lateral branches begins to reach upwards and replaces the main stem of the podetium.

When the recovery of the podetium takes place by way of replacing the main stem by a lateral branch then the sprouting process proceeds more rapidly. The lateral branch grows at about the same rate as the main stem. The age of the lateral branches, that remain after the removal of the tops, is usually from 3 - 5 years. Therefore, the recovery begins immediately from the 3rd or the 5th year. To this age a high growth-rate is already peculiar and during the first year the podetium grows 3-5 mm. In view of the fact that the old podetium during this "course" of the growth of the new podetium has not yet had time to die off, but even continues to grow a little, the recovery of the original height and of its mass -in a practical sense- takes place during 2-5 years.

The regularities noticed in the recovery of the podetia, that were established on the basis of experiments on test plots and on observations in nature or in the open are confirmed by experiments and the experience of reindeer breeding. In December of 1947 - at the NARYAN-MAR experimental reindeer breeding station- a herd of reindeer was pastured on a test plot of a reindeer-moss pasture (the test was conducted by A.V. VAZINGER-ALEKTOROVA). In 1951, the survey of the food reserves, carried out by G.I. KAREV, disclosed that in the places that had been superficially tramples or browsed over by the reindeer (at ½ of the height of the

podetium) the recovery of the reindeer moss was complete; whereas in those places where 70-80° of the reserves had been removed hardly and signs of recovery were noticeable. But the holes -where the reindeer moss had been consumed- which are the bottom of funnel- shaped pits dug by the reindeer in the snow, stood out sharply on the lichen-cover.

According to the reindeer herders the holes on the winter pastures remain noticeable for 5-6 years if there has been no grazing after this. In some cases as a result of more intensive grazing upon reindeer moss the holes remains for a longer time.

The recovery of the mechanically damaged podetium occurs in a similar manner with the growth of the new podetium. The sprouting of a podetium that was "bitten off" by reindeer -in most cases- occurs at the same rate as the formation of the podetium during the first year of its existence, only instead of the original thallus the remaining base ("the stump") of the old podetium serves as the basis for the development. The rate of the sprouting and the time needed for a full recovery of the podetium depend on the size of the remaining base. When 2/3 or 3/4 of the height of the podetium are removed then the recovery takes place during a period that equals the duration of the first period of the existence of the podetium, which is determined by the number of the joints in the living part of the podetium. When the damage is severe (removal of the entire living part) the time of the recovery is lengthened by 3-5 years or the podetium dies completely. When the damage slight (the removal of the top, which comprises less than ½ of the height of the podetium) the time for the recovery is about twice as short (depending on the dimensions of the removed top and the size of the remaining base).

The observed peculiarities of the growth and the recovery of the podetium should find their explanation in the peculiarities of the biology of the lichens. It is known that the thallus of the fruticose lichens are poorly differentiated functionally. The cells of the algae of all the parts of the living thallus participate in the assimilation process. The larger the mass of the thallus is, the more intensive is the metabolism and the growth-processes can be "realized" the quicker. Experimental data speak of the fact that the larger podetia grow faster, i.e. the sprouting processes are the faster the larger the part of the podetium participating in them is.

Hence a rather important practical conclusion: In order to get more fodder from the pastures one must preserve a large food-producing mass on them. It is better to make use of the pastures gradually, but more often, than to gather from them a larger amount of fodder over longer periods of time. Every year the yield of fodder in the first instance will be considerably higher and the natural resources will be utilized more rationally.

In conclusion of our study of the growth-peculiarities of the podetium, it should be observed that the podetium represents a peculiar part of the organism that renews itself for a considerable length of time. The separate parts of the podetium, its joints, develop and age relatively rapidly. But the podetium, as a whole, experiences considerably slower changes in the growth, which at the beginning of the life are related to the accumulation of the living mass and depending -during the entire life-span- upon the effect of the external conditions upon it.

The life of the podetium is related to the processes of the appearance, growth and death of the individual joints. The interrelations of these processes bring about the ap-

appearance or occurrence of definite periods in the life of a podetium. The prevalence of the processes of the appearance and growth of the joints is characteristic of the first period of the lifeof a podetium, an approximate balance between the appearance and the dying off of the joints -for the second period and a prevalence of the dying off-processes- for the third period.

A change in the conditions of the outer or external medium determines the duration of the various periods and the growth-rate during each of the periods.

T.D. LYSENKO repeatedly stressed the difference between the development of a plant and its growth (1952, I). Development stages -differing qualitatively- have not yet been established for lichens. However, one should assume, that the annual regular branching of the podetium is preceded by a definite development-stage, through which the branching joint passes, under conditions created by a certain temperature-regime. Only if there is a similar "stage-arrangement" is it possible to understand the fact of the annual branching of the podetium.

The peculiarities of the growth and development of the lichen -of this- according to the apt remark by K.A. TIMIRYAZEV- "plant-sphinx" (1948) are not yet disclosed. At the moment to us are known, only in general, the external aspect of these processes. This, though imperfect, knowledge, nevertheless, makes it possible to affect to a certain extent the processes of the growth and recovery of the podetium.

III. Methods for the study of the growth and renewal (sprouting) of the fodder lichens.

The economical utilization of the fruticose lichens (mainly as pastures as well as a probable raw material for industry) must provide for the following: Firstly, the use of only those reindeer moss stands in which the podetia have fully completed the first period of existence as a result of which there was created a reserve of reindeer moss, which later on hardly

increases; secondly, not to permit, under conditions of proper utilization, the reindeer moss to become overripe; i.e. its prolonged "stay" in the second period of its existence, during which the growth of the living mass is balanced or equalized by its useless loss as a result of the dying off of the base of the podetia; thirdly, the creation of conditions for the quickest possible full recovery of the reindeer moss that has been used.

In order to meet these demands of the industry it is necessary to know the duration of the growth-accumulation period and the amount of the reserves created by the end of this period.

What do the suggested methods for establishing the growth contribute to the solution of the questions posed? We have already dealt with the shortcomings of the TENGWALL method. We cannot accept the method of PALMER (PALMER and ROUSE, 1945), who established a number or series of "stock-taking or checking" areas on the reindeer grazing grounds in Alaska. On these areas he clipped the reindeer moss to imitate the grazing of the reindeer. This crudely empirical method which does not take cognizance of the biological peculiarities of the processes of the growth and recovery of the reindeer moss does not make it possible to use the obtained material beyond the confines of the "stock-taking or checking" area; furthermore, it requires prolonged periods of time to obtain any kind of data.

The methods of the Soviet researchers differ basically from the methods of TENGWALL and PALMER. The former proceed from the biological peculiarities of the development of the lichens and are directed at a further discovery of the laws governing the development and are aimed at mastering them. However, as stated above, the methods of the Soviet researchers differ from each other and throw light upon the various aspects of the development of the lichens.

The "mark" method suggested by B.N. GORODKOV (1936) makes it possible to establish the amount of growth for one year or for still shorter periods of time. In order to establish the duration of the period of the growth-accumulation and the mean amount of the growth-increase, that is peculiar to this period, this method calls for long-term experiments (not less than 10-15 years). This obviates its practical application on a large scale.

The method by A.I. MALAKHIN (1937) makes it possible to determine the growth only during the renewal period of the podetium, seeing that the length of the joint, that has ceased to grow, characterizes the extent of the growth of the podetium, which has attained maturity and has entered upon the second period of existence. This amount or value is not of interest, seeing that the growth during the second period does not facilitate an increase in the food reserves. The extent of the dying off can be of importance in the study of the problems of turf or peat-accumulation and of the extent of the influence of the lichen-cover upon the soil-forming process.

The method of the average or middle joint suggested by K.N. IGOSHINA (1939) can neither provide the required material, seeing that the "average or middle joint" for a podetium, as a whole, is an incidental value, which, in the first place, depends upon the dimensions of the dead part of the podetium with the longest joints. In the younger podetia or in the old ones, which are not in "good decomposition-conditions" with regard to the organic substance the dead part of the podetium will be short. In the older podetia which grow under poor "decomposition-conditions" regarding the organic matter the dead part will be long. In the first place, the "average or middle joint" will be considerably shorter than in the second, although the amount of the factual growth-increase may not correspond to this.

2. Establishing the duration of the growth-accumulation period and determining the dimensions of the linear growth.

The method suggested by us in 1940 makes it possible to establish the duration of the growth-accumulation period and the average linear growth during the period. As mentioned above, this is achieved by measuring the length of the living part of the podetium, that has completed the first period of existence and has entered upon the second period, and a count of the number of joints in the living part.

In order to obtain comparable material all the measurements are made in an ultimate-humid state. In some cases when it is necessary to reduce the data to an air-dry condition the coefficients obtained by G.I. KAREV at the NARYAN-MAR reindeer breeding station, which differ somewhat from the data by T.P. NEKRASOV. (1937) and B.N. GORODKOV can be used (1935). It was established by the experiments of KAREV that the lengthening of the living part of the podetium in an ultimate humid state comprises, in the mean, in the case of the main forage species of the Cladonias 20% of the length in an air-dry state (instead of 13.7% by NEKRASOVA and 18% by GORODKOV) and in the living part of the thallus of Cetraria nivalis -- 35%. Therefore in order to establish the length of the living part of the podetium in an air-dry condition one must, in the case of the Cladonias, reduce the value in an ultimate-humid condition by 17% (the length in an air-dry condition comprises $\frac{100 \times 100}{120}$ = 83% of the length in an ultimate-humid condition) and in the Cetrarias by 26% ($\frac{100 \times 100}{135}$ = 74%).

In some cases, one may need the amount of the growth during the period of the renewal or rejuvenation of the podetium. Practically it is most convenient to establish it by the length of the bottom joint in the base of the living part of the podetium. Measuring several joints in the dead and dying parts of the podetium produces less accurate results in view of the disintegration of the organic matter and the change in the

length of individual joints. A comparison of the mean values of the growth during the growth-accumulation period and during the renewal-period of the podetium shows that a definite or certain dependence exists between them. The mean growth during the first period of the development of the podetium comprises 60-70% of the length of the bottom joint. In the areas of the forest-tundra this value or amount comprises, in the mean, 60% and in the "taiga" areas -- 68% (see table 3).

Table 3.

Interrelation between the values of the growth of the podetium during the various periods of its existence.

1 - Species of lichens and where collected. 2 - Height of living part of podetium (in mm). 3 - Age of living part of podetium. 4 - Average growth during the growth-accumulation period (in mm). 5 - Mean growth during the period of the renewal of the podetium (in mm). 6 - Mean growth during the first period in % from the growth during the second period. 7 - Number of specimens.

a - Murmansk region. b - YAMAL peninsula. c - YAMAL peninsula. d - basin of the BUREYA river. e - YAMAL peninsula. f - basin of the BUREYA river. g - Mean and total.

Thus by having the data on the mean growth during the first period to hand it is possible to determine approximately the value or amount of growth during the renewal period of the podetium. For this one must use the coefficient 1.7 for the forest-tundra areas and 1.5 for the "taiga" areas. It is easy to check these coefficients. In order to do this one must take a normally developed podetium with a dead base, soak it in water, measure the total length of the living part, count

the number of joints in it and measure separately the length of the bottom living joint. In most cases the last value will exceed by 1.5-1.7 times the quotient from the division of the living part of the podetium by the number of the joints (the mean linear growth during the growth-accumulation period).

In some cases, perhaps, the amount of growth for a definite period of time, e.g. for one year, may be required. A morphological analysis of the podetium in view of the fact that the separate joints represent the result of the growth over a number of years yields the summary or total mean amount of growth for the entire existence of the given joints. In order to establish the amount of growth for a definite shorter period of time, independent of the life-period through which the podetium is passing the only method that can be applied is the "mark" method suggested by B.N. GORODKOV.

In some cases the method of analysing the length of the individual joints of the living part of the podetium can be used for establishing the rate and peculiarities of the course of the growth-accumulation. The method consists of measuring each joint separately and of determining -on this basis- the intensity of the growth-accumulation process. For this purpose one should take at least 50 specimens of one species from one and the same locale. Table 1 shows that the stretching or extension of the joints in the lichens of the taiga zone (the [illegible] river) proceeds more intensely than in the forest-tundra. Already during the third year the joints in the "taiga" attain 40-50% of the size of the largest bottom joint, whereas in the forest-tundra -at this age- they only reach 20-30%; during the fifth year the size of the joints in the "taiga" comprises about 75%, in the forest-tundra -45-60%; during the seventh year in the "taiga" - 90-95%; in the forest-tundra - 70-85%. In keeping with this the height of the podetium in the "taiga" increases more rapidly than in the forest-tundra. This is shown by drawing 6.

<u>ering 5</u>. Growth of the podetium of Cladonia sylvatica during the growth-accumulation period according to data of the analysis of the length of separate joints. 1 - in the forest tundra. 2 - in the "taiga"

a - height of podetium in cm. b - age of podetium in years.

3. <u>Determining the mass or bulk of the annual growth</u>.

It is rather important, for practical purposes, to have data on the mass or bulk of the increase through growth to hand. When one possesses data on the linear dimensions one can still not judge about the concrete dimensions of the mass. We used two ways for ascertaining the course of the accumulation of the living mass of the lichens: Firstly, a study of the change in the weight of an individual podetium depending on the age and, secondly, a study of the changes in the reserves of the mass or bulk of lichens in the covers depending on the age and the height.

In the Murmansk area in the pine forests along the [illegible] river V... KOV...KINA, a geobotanist, at our request, collected and weighed 690 podetia of various ages. This material, processed by us, is presented in Table 4.

Table 4

Height and weight of podetia depending on the age (Murmansk region). (Height in a humid condition; weight in an air-dry condition.)

1 - age; 2 - height (in mm); 3 - weight of one podetium (in mg); 4 - height (in mm); 5 - weight of one podetium (in mg); 6 - height (in mm); 7 - weight of one podetium (in mg).

a - 7-10 years; b - 11-15 years; c - 16-20 years.

Similar work was done by A.V. VAZINGER, a geobotanist, in the forest-tundra in the NENETSKI National District. She collected and weighed 10664 podetia of Cladonia sylvatica. This material processed by us, is in Table 5.

The adduced data show that the increase in weight takes place not in proportion to the height, but considerably faster. This is quite plain, if one considers the fact that a large part of the mass is created at the cost of the repeated branching of the lateral branches. In the case of the Cladonia alpestris, which has the most ramified podetium, the acceleration of the accumulation of the moss or bulk in comparison with the increase in the height of the podetium is exceptionally high. (Drawing 7.) This fact points out the principal incompetence of the method for determining the bulk of the annual growth of the lichens which is based upon a survey of the height of the living part of the lichen-cover, the weight of the lichen-moss and the yearly growth of the lichens ($\frac{\text{weight of lichens} \times \text{growth in height}}{\text{height of living part}}$), which was used until recently.

Table 5.

Height and weight of the podetia of Cladonia sylvatica depending on the age (NENETSKI OKRUG). (Height in humid state; weight in an air-dry state.)

1 - age; 2 - height (in mm); 3 - weight of one podetium (in mg).

a - total; b - for 1 cm of height; c - the mean.

We will adduce some data that characterize the changes in the moss of the lichen cover depending upon its height and age.

Drawing 7. Increased heights and weights of the podetium of Cladonias depending on the age.

1 - age (in years); 2 - height (in cm); 3 - weight (in mgr.) Cl. alpestris; 4 - weight (in mgr.) Cl. sylvatica.

On the basis of the processing of harvests or cuts gathered from lichen covers consisting of plants of more or less the same age, we established a sharp drop in the reserve of the moss per 1 cm of the height of the podetium which takes place as the height of the podetium is increased. Thus, for instance, according to the data on more than 5000 harvests or cuts, from the northern part of the basin of the PECHORA river we get the following series. If 100% is accepted as the mass of the lichens (with a prevalence of Cl. sylvatica) in the conversion to 1 cm of the height at a mean height of the living part of the podetium of 2 cm, then at 3 cm we get 82%, at 5 cm - 63%, at 7 cm - 48%. Similar values were obtained by A.T. REUTT on the basis of the processing of 1000 harvests or cuts, that were gathered on the KOLA peninsula (with a prevalence of Cl. alpestris): at a height of 2 cm - 100%; 3 cm - 80%; 5 cm - 70%; 7 cm - 60%.

The cause or reason for this phenomenon lies in the fact that the differences in the height of the podetium of lichens of the same age are occasioned by the uneven or different rate of the growth of the podetium and, due to this, by the extent of its ramifications. In the taller podetia there are fewer lateral branches per 1 cm of height than in the lower ones. In connection with this the weight of a heavier top with tiny branches in a conversion of the total weight to 1 cm of height is distributed in the taller podetia over a larger number of centimeters.

A comparison of lichen-covers of plants of various ages out of a uniform height shows an increase in weight in keeping with the "increase" in age. According to our data from the northern part of the PECHORA region the weight of a 12-year old lichen-cover comprised 80% and that of a 10-year old ~~lichen~~ cover ~~comprised~~ - 70% of the weight of a 14-year old stand of reindeer moss (in a conversion to 1 cm of height). The heaviest are the lichen-covers of the tundra, where the growth is slowed down most and the lightest are the lichen-covers of the

forest zone where the growth is considerably faster (see Table 6).

Table 6.

Reserves of lichens (with a prevalence of Cladonia alpestris) in the "taiga" and in the tundra. (In centners per ha of an air-dry mass in a conversion to 100% of the true covering or layer).

A - where collected; B - Tundra; a - reserve: 1 - height(in cm); 2 - age; 3 - annual linear growth (in mm); 4 - total; 5 - per 1 cm of height; 6 - number of cuts.

C - Taiga; a - reserve: 1 - age; 2 - annual linear growth (in mm); 3 - total; 4 - per 1 cm of height; 5 - number of cuts.

I. Northern PECHORA river (NENETSKI NATIONAL district and the UST-TSILEMA area).

II. The KOLA peninsula (the TERIBERKA and SAAMI districts).

III. Mean reserve per 1 cm of height.

In the event of simultaneous change in the height and in the age, which occurs when young or new reindeer moss covers grow up and when the pastured reindeer moss stands are recovered, there takes place a more rapid increase in height. Of this testify the data from 50 areas with Cladonia sylvatica on which cuts had been made. The latter were made in the NARYAN-MAR area in a fir-birch forest with the same local conditions (Table 7).

A comparison of the obtained data with the data on the increase of the bulk of an individual podetium (Table 5) shows that the accumulation of a mass in a cover proceeds at a faster rate (Table 8).

Table 7.

Height and weight of the living moss of Cladonia sylvatica in a lichen-cover depending on the age.

1 - Age of the predominant moss of podetia. 2 - Height (in cm). 3 - Covering (in %). 4 - weight in centners per ha; a - total; b - per 1 cm of height.

Table 8.

Comparison of the course of the accumulation of the moss by an individual podetium and, as a whole, by the lichen-cover in the case of Cladonia sylvatica.

A - age; B - weight of living mass (in %).

1 - of an individual podetium. 2 - in a lichen-cover.

a - on the whole; б - per 1 cm of height; c - on the whole;

d - per 1 cm of height.

The more rapid process of the accumulation of a vegetative moss in a cover is occasioned by a certain difference in the age of the lichen-covers. The researches carried out by V.A. KOVALKINA disclosed that usually the moss of the prevalent coeval podetia is joined by a certain number of plants with a living part of the podetium of a different age. Table 9 shows on the basis of an analysis of the test plots of 1/4 m^2 - the composition of the podetia according to the age of their living part (the podetia of all age-groups are in the second period).

Table 9.

The age-composition of the living part of the podetia of Cladonia alpestris (in %) under various conditions (KOLA peninsula).

A - Growing conditions. B - Age of the living part.

1 - Fir forest; 100% covered with reindeer moss.

2 - The same. Reindeer moss covers 50%.

3 - Pine-lichen forest. 4 - Fir-birch moss-lichen forest.

5 - Sphagnum-lichen swamp.

The ability of a lichen-cover, even if it consists of specimens of one species, to separate into groups of specimens of a different age and a different length of the living part of the podetium makes it possible for the lichen-community to utilize the local conditions more fully.

The way of the study of the ontogenesis of separate podetia is not suitable for the study of the accumulation of the living mass of the lichens. It is necessary to study directly

the changes in the weight of the lichen-cover when the height and weight of the basic mass of the podetia vary.

On the basis of this method we succeeded in establishing some peculiarities in the course of the accumulation of the living moss of the lichens. During the first period of the existence of the podetia there occurs -at an ever increasing rate - an accumulation of growth and an increase of the living moss. The details of this process are not yet fully established. It can only be stated with certainty that the increase of the bulk or moss is more intensive than the increase in height and is governed by its own rules of the growth of the podetium, but it should be studied by means of biological methods.

The young lichen-covers that reached the period of growth-renewal, when the increase in the height of the living part of the podetium ceases, continue, for a while, to accumulate the living moss at the cost of the growth of lateral branches. In the species with a more ramified podetium (Cl. alpestris) the accumulation of the living moss is drawn out over a period, it seems, of fewer than 4-5 years after the close of the growth-accumulation. In species with a less ramified podetium this period is shorter. In a number of cases the accumulation of the bulk stops simultaneously with the cessation of the increase in height of the living part of the podetium.

In the subsequent course of the development of the lichen-cover during which the main part of the podetia is in the second period certain changes in the reserve of the living moss transpire only under the influence of changes in the conditions of the outer medium or environment and in the interrelations that arise in a community between the species that comprise it.

The above discloses not only the complexity of the concept of the "mass of the annual growth" of the lichens but also the fallibility of the methods to establish its existence. The mass of the annual growth of the lichens changes during the various periods of the existence of the podetium. If during the first period the growth of the bulk increases every year it must be said that during the second period, with the exception of the first few years, as a rule, there is no increase. The concrete values or amounts of the mass of the annual growth cannot be established on the basis of the data on the linear growth. In order to obtain them one must make cuts -in series- from specially selected lichen-covers differing in age occurring in communities of a varying type. It is very difficult to put this through on a grand scale and it is not warranted by the interests of the industry. In order to obtain material -on a large scale- that is required for organizing the proper use of lichen grazing grounds in the interest of reindeer breeding we suggest the development of two indicators: The largest reserve of the living mass of the lichens reached at the beginning of the second period of the existence of the podetium and the time required to restore or recover moss utilized in grazing.

A similar method has already been advanced in literature. V.K. ARYMOV suggested to divide the reserve or stocks of the reindeer moss into the 35 years of its recovery to establish the probable bulk of its "annual offshoot of reindeer moss" (1928). A.A. DEDOV, in order to establish the "mass of the annual growth of reindeer moss", suggested to divide the reserve, in the mean, by the 20 years of its recovery (1932). V.B. SOCHAVA recommended the same method. He advanced a still more modest duration of the recovery - 15 years (1934). However, none of the enumerated authors at that time could give a definite answer to the question what reserves of the reindeer moss should be taken into consideration and of what nature is the variability

of the time of its recovery in dependence upon natural factors and the activity of man. If this question is answered then the objection of B.N. GORODKOV, who pointed out the incompetence of a similar method seeing that no cognizance was taken of the loss of part of the food reserves due to the decomposition of the reindeer moss from the bottom, becomes invalid (1936, p. 89).

The reserves of mature or fully grown reindeer moss are established by the commonly accepted methods of determining the food reserves on pastures. One can use tables for tentative determinations on a large scale. These tables furnish the amounts of the reserve depending on the age and height of the lichens. Similar tables are compiled for the separate species based on numerous cuts made according to a certain or definite plan -from covers with a varying height and a varying age, but, in every case, with podetia, that had reached the second period of existence. The table on the reserves of Cl. sylvatica, which was compiled by us on the basis of 5277 cuts in the "PECHORA NORTH" can be used as an illustration (see Table 10). Some figures, especially those in the right hand part of the table, were derived by means of extrapolation.

Table 10

Reserve of the living mass of Cladonia sylvatica in the PECHORA NORTH (in centers per ha with a 100% covering).

1 - height of living part in cm. 2 - duration of the first period (in years).

The following are encircled: In the left hand top rectangle - the most dense amounts or values of tundra reindeer moss stands, in the middle one - for the reindeer moss stands in the forest-tundra, in the bottom - right side - for the reindeer moss stands in the northern part of the forest zone.

The time, required for the recovery of the used bulk of lichens, is determined by a morphological analysis of the

podetium (height of the living part of the podetium that has reached the second period of existence and the number of joints in it) as well as noting the mean height at which the podetium was "bitten off", followed and recommended under concrete conditions. As mentioned above, the time needed for the recovery of the podetium depends upon the height at which it was bitten off. If 2/3 - 3/4 of the height (i.e. 70-80% of the entire stock of the living mass) are removed then the recovery-period equals the duration of the first period of the existence of the podetium; if almost the entire living part (i.e. 90-100% of the entire reserve) is removed then the recovery, if it takes place, nevertheless, will require a much longer period of time; if 1/4 - 1/3 of the height of the podetium, i.e. its top, which contains 40-50% of the reserve, is removed then the recovery takes place within 3-4 years. Thus after intensive grazing on the pastures the mass of the annual growth during the recovery of the reindeer moss, in the mean, comprises the following (for instance, if the first period lasted ten years): When the grazing was close (to the ground. Tr.)- 6-7% of the total reserve, when the grazing was at middle height (at 2/3 - 3/4 of the podetium) -- 10% of the total reserve, when the grazing was superficial - 12-15%.

The value or amount of the annual growth of the mass of the reindeer mosses, which to a considerable extent determines the capacity of the grazing territory should be regarded as depending not only upon natural factors but also upon the methods used in pasturing the reindeer. The latter circumstance opens wide vistas for increasing the productivity of the reindeer pastures and improving the methods for the pasturing of reindeer.

Methods for determining the capacity of the pastures without recognizing the conscious and transforming activity of man should be regarded as unsuitable. The mass of the annual growth-increase of the reindeer moss under the same natural

conditions, as a result of changes in the pasturing methods, can be increased considerably.

IV. Growth of the forage lichens depending on the living conditions.

In order to establish the growth of the fruticose lichens we used the following indicators: Firstly, the height of the living part of the fruticose thallus (the podetium in Cladonia), which has attained to full maturity, i.e. which has entered upon the second period of its existence (life); secondly, the number of joints in the living part of the podetium, which usually characterizes the duration of the first period of existence.

On the basis of these indicators one establishes the representative value of "the average annual linear growth". It is established by dividing the length of the living part of the podetium by the duration or length of its existence. This indicator characterizes the intensity of the growth and is the derivative of the first two.

The amount of the linear growth of the reindeer moss is significant as an approximate indicator of the general course of the accumulation of the mass under various growing conditions. The growth of the mass ~~under~~ is the function of not only the linear growth, which reflects the growth of the podetium upwards, but also of the degree of the closeness (density), that reflects the growth of the lateral branchings. The changes in the latter value in the course of the development of the lichen-covers have not been studied sufficiently. Due to this, at the moment, it is difficult to establish the exact quantitative dependence between the linear growth and the growth of the mass. For this reason the latter value is practically established on the basis of specially gathered cuts.

In this work we use the indicators of the linear growth for establishing the dependence of the growth upon the living conditions of the lichens. These indicators can be collected

with great exactitude and in great numbers. On their basis the general laws of the growth can be fully ascertained. The data on the growth of the mass in some areas, on the basis of the ascertained laws, can be extended also to those areas and x types of pastures for which the material on cuts, that is needed for determining the growth of the mass, is still lacking.

Samples of lichens collected according to one method in 1940-1941 and in 1951 on the territory of the NENETSKI National District and the northern regions of the KOMI A.S.S.R. were used as material in the study of the enumerated indicators.

The samples were selected from lichen-covers, which had completed the first period of their existence and were now in the second period. The outward distinguishing marks or features that governed the selection of the samples were the presence of the dead part of the podetium, with at least 3-4 joints, and the absence or lack of mechanical damages to the podetium, which had the entire range of the joints from the dying long joints in the base to the tiniest branches at the top. The samples were selected in such a way that one could select from each 10 normally developed podetia for chamber (?) processing.

In order to obtain the mean values that characterize, on the whole, the territories under study with their different conditions, the samples were collected along the course followed by the geobotanical survey. The places where the samples were gathered were distributed more or less evenly over an area of about 250000 km^2. The samples that belonged to one and the same formations were gathered from various geographic points, not more than two samples were taken at one place.

The samples were taken from basic communities, with a greater or lesser participation of fruticose Cladonias in their composition.

All the measurements were made in an ultimate-humid state. More than 30% of all the samples, for the sake of checking, were measured twice. The material was processed in the town of NARYAN-MAR under our supervision. The preliminary results were (ANDREYEV, 1947) published in part.

In the fully processed data were included 6255 specimens collected by the geobotanists of the BOLSHEZEMELSKAYA expedition of the NKZ (People's Commissariat for Agriculture. Tr.) of the RSFSR and 898 specimens collected by the geobotanists of the experimental reindeer breeding at NARYAN-MAR. In the years that followed material was gathered and processed according to our method on a number of areas in the Far North. We have at our disposal material on the geobotanical work of the expeditions of MKH (perhaps: Department of Agriculture. Tr.) of the RSFSR on the MURMANSK oblast on 5165 specimens (1948) and on the CHUKOTSKI National District on 6455 specimens (1950 and 1951), where this work was carried out under the direction of A.T. RUTTT, on the northern part of the KAMCHATKA peninsula on 1705 specimens (the work was directed by N.I. TEZNOEV in 1948-1950), on the KOZHVINSK rayon of the KOMI A.S.S.R. on 250 specimens (collected in 1951), on the basin of the BYRRYA river on 5120 specimens (collecting and processing under the direction of A.T. RUTTT in 1949). The enumerated materials that were collected under the conditions of expeditionary work in various areas, are of great interest and are used by us in part for comparison. Also for comparison were used the following materials that were collected under conditions of station-research at the experimental network of the Scientific-Research Institute for Arctic agriculture, animal husbandry and hunting, namely: In the PECHORA forest-tundra -- 10894 specimens (VALINGER-ALEKTOROVA), in the YAMAL forest-tundra -- 1000 specimens (KIKKI (KILDYUSHEVSKI) in the northern taiga of the Murmansk oblast -- 690 specimens (KOVALKINA), in the ANADYR forest-tundra and tundra -- 900 specimens (AVRAMCHIK). In all we use data on the growth of 37,500 specimens of lichens that belong to three species of Cladonias

(Cl. alpestris, Cl. sylvatica, Cl. rangiferina).

Of the data on the growth of lichens published in literature we cannot use anything for comparison save the general directions by G.I. TANFILYEV (1894, p. 24; 1901, p. 8; 1911, p. 34) and B.N. GORODKOV (1933, p. 152; 1935, p. 73; 1938, p. 321).

The materials by KRABBE (1891, p. 131), that were obtained on the basis of observations with regard to Cl. rangiferina, that developed from soredia (brood-buds. Tr.), carried into fresh burns of a pine forest and grew bushes -in ten years- 3-5 cm in height, were thoroughly dealt with in literature. KRABBE does not make any mention about the beginning of the decomposition of the bushes from the bottom. It is possible that the decomposition set in a long time ago and in that case the value of an annual growth of 3-5 mm is exaggerated. If the decomposition had not yet set in then this value must be regarded as under-estimated seeing that in the subsequent development the extent of the growth should have been enlarged. Furthermore, on burns, this was pointed out, long before the work by KRABBE appeared, by MIDDENDORF (1869) and by the work of B.A. TIKHOMIROV (1933) and other researchers, there are created conditions during the first years after a fire that are unfavorable for the growth of lichens. All this, in view of one single observation, compels us to regard the data by KRABBE as insufficient for judging the actual extent of the growth of the lichens.

The data by TENGWALL (1926) and by SAMBUK (1936), which are based upon the faulty method of the datum mark do not merit attention. The work by NEKRASOVA (1937; 1938), which is based upon the "mark" method, furnishes only the extent of the growth during the second period of the existence of the

fruticose thallus. It is somewhat under-estimated, for the marks did not encompass the entire living part of the podetium. The work by GALAKIN (1937) also adduces the dimension of the growth during the second period of existence, but they are also somewhat underestimated; for the author used the deformed joints of the decomposed base of the podetium to establish the length of a "mature joint". The data by IGOSHINA (1939) correspond approximately to the mean growth during the first period of existence. But they are somewhat exaggerated because a certain number of long joints from the decomposed base of the podetium was included in the calculation concerning the "mean or middle" joint. In tabulated works (ANDREEV, 1940; R.BOTNOV and GOVORUKHIN, 1950; GOVORUKHIN, 1950) where there are adduced -on the individual areas- the values of growth - that cannot be compared- on the various periods of existence. The values were obtained by various methods. Furthermore, the number of the specimens studied was negligible.

Our data on the three basic species of Cladonia are adduced in Tables 11, 12 and 13.

The following deductions emerge from the above material: Firstly, the amount of growth and the duration of the first period of existence differ in the various species; secondly, these peculiarities of growth are subject to the law of zonality and also depend on the degree of the continentality of the climate; thirdly, they change in dependence upon the nature of the vegetation and reflect a number of peculiarities of the locale and of the interrelations that arise during the process of the development of the community between its various components.

We will deal brief with each deduction.

1. Growth - peculiarities of various species of lichens.

Of the three species of Cladonia studied Cl. rangiferina is distinguished by the most rapid growth in height, Cl. alpestris shows the slowest growth and height Cl. sylvatica occupies the

intermediate position. Table 14 presents a comparison of the values of the growth of the various species under various conditions.

Plants -within the scope of the comparable series- were selected for the various species; they were about the same in regard to the duration of the first period of the existence of the podetium.

Table 14.

Mean annual linear growth of the various species of Cladonia during the growth-accumulation period.

1 - Area and vegetation. 2 - in mm. 3 - in %. 4 - number of specimens.

a - PECHORA North, subzone of southern tundra. b - The same place, subzone of the tundra of sparse tree-growth . c - Left bank of the lower reaches of the PECHORA river, southern tundra. d - the same place, subzone of the northern taiga. e - MALOZEMELSKAYA tundra, sparse fire stands. f - BOLSHEZEMELSKAYA tundra, thinned out fir stands. g - MURMANSKAYA oblast, the PONOY river, northern taiga. h - KAMCHATKA, the TIGIL river, mountain tundra. i - The same place, belt or zone of the ground cedar. j - Mean and total.

The above data show that the growth of Cl. alpestris comprises -in the mean- 87% of the growth of Cl. sylvatica, with fluctuations within the range of 61-95% in the various areas and the plant communities of the Far North. The growth of Cl. rangiferina comprises -in the mean- 115% with fluctuations within the range of 105-135%.

In tables 11, 12, 13 in some cases Cl. alpestris discloses -within the scope of uniform formations- a large increase in growth in comparison with Cl. sylvatica. However, it is easily seen that in these cases a comparison of the taller and lesser later developing specimens of Cl. alpestris with the lower and earlier developing specimens of Cl. sylvatica is made.

Individual species also differ with regard to the height of the living part of the podetium and the duration of the first period of its existence of the three main species of reindeer moss Cl. alpestris reaches the greatest height and is characterized by the longest duration of the growth-accumulation period. The mean height of the living part of the podetium of this species in the PECHORA NORTH is from 4 cm in the tundra to 6 cm in the taiga zone, on the KOLA peninsula - from 4.5 cm in the tundra to 6 cm in the taiga zone, in the tundras of the CHUKOTSKI peninsula -- 6-7 cm. Individual specimens can grow considerably taller, up to 20 cm (ELENKIN, 1911, p. 490). The first period of existence, in the mean, continues in the PECHORA North as well as on the KOLA peninsula for 12-13 years, on the CHUKOTKA for 16-18 years.

Table 11.

Height of living part of the podetium, length of growth-accumulation period and the mean linear annual growth during this period in the case of Cladonia alpestris on the PECHORA North according to the subzones and vegetative formations.

1 - Insert. 2 - Height of the living part of the podetium (in cm). 3 - Length of the growth-accumulation period (in years). 4 - Mean linear annual growth during the growth-accumulation period (in mm). 5 - Number of samples.
a - Subzones and vegetative formations. b - MALAYA ZEMLYA. c - Western part of BOLSHAYA ZEMLYA. d - Eastern part of BOLSHAYA ZEMLYA. e - In the mean. f - MALAYA ZEMLYA. g - Western part of BOLSHAYA ZEMLYA. h - Eastern part of BOLSHAYA ZEMLYA. i - In the mean. j. - MALAYA ZEMLYA. k - Western part of BOLSHAYA ZEMLYA. l - Eastern part of BOLSHAYA ZEMLYA. m - In the mean. n - MALAYA ZEMLYA. o - Western part of BOLSHAYA ZEMLYA. p - Eastern part of BOLSHAYA ZEMLYA.
I. Subzone of Arctic tundra. Lichen-tundras.
II. Subzone of northern tundra. Lichen-tundras.
III. Subzone of southern tundra. Lichen-tundras.
Tundras with stands of birch. Hilly tundra swamps.

IV. Subzone of the tundra sparse forests. Lichen tundras. Tundras with stands of birch. Hilly tundra swamps. Sparse fir stands.

V. Subzone of the forests near the tundras. Tundras with brich stands. Hilly tundra swamps. Sparse stands of larch. Sparse fir stands. Thinned out fir forests. Pine-lichen forests. Ridged marsh-sedge bogs.

VI. Subzone of northern taiga. Thinned out fir-forests. Pine-lichen forests. Pine sphagnum forests. Ridged marsh-sedge bogs.

VII. Arctic Ural mountains (western slope). Lichen-mountain tundras. Mountain tundra with birch stands. Sparse mountain birch forests.

VIII. Remark: M - mean value; $\pm$ M- probable error. C - coefficient of variability.

Table /2

Height of the living part of the podetium, length of the growth-accumulation period and the mean linear annual growth during this period in the case of Cladonia sylvatica in the IEGHORA North according to the subzones and vegetative formations.

1 - Inset 2. 2 - Height of living part of the podetium (in cm). 3 - Duration of growth-accumulation period (in years). 4 - Mean linear annual growth during the growth-accumulation period (in mm). 5 - Number of samples. a - Subzones and vegetative formations. b - MALAYA ZEMLYA. c Western part of BOLSHAYA ZEMLYA. d - Eastern part of BOLSHAYA ZEMLYA. e - Mean. f - MALAYA ZEMLYA. g - Western part of BOLSHAYA ZEMLYA. h - Eastern part of BOLSHAYA ZEMLYA. i - Mean. j - MALAYA ZEMLYA. k - Western part of BOLSHAYA ZEMLYA. l - Eastern part of BOLSHAYA ZEMLYA. m- Mean. n - MALAYA ZEMLYA. o - Western part of BOLSHAYA ZEMLYN. p - Eastern part of BOLSHAYA ZEMLYA.

I. Subzone of Arctic tundra. Lichen tundras.

II. Subzone of northern tundra. Lichen tundras.

Tundras with birch stands. Hilly tundra bogs.

III. Subzone of southern tundra. Lichen tundras. Tundras with birch stands. Hilly tundra bogs. Sparse fir-forests.

IV. Subzone of sparse forests in tundra. Lichen-tundras. Tundras with birch stands. Hilly tundra bogs. Sparse fir-forests. Thinned out fir-forests.

V. Subzone of forests near the tundras.
Tundras with birch stands. Hilly tundra bogs. Sparse larch forests. Thinned out fir forests. Pine-lichen forests. Ridged marsh-sedge bogs.

VI. Subzone of the northern taiga.
Thinned out fir-forests. Pine-lichen forests. Ridged marsh-sedge bogs. Pine sphagnum forests.

VII. Arctic Ural mountains (western slope)
Lichen mountain tundras. Tundras (mountain) with birch stands. Sparse birch forests (mountain).

VIII. Remark: M - mean value; $\pm$M — probable error; C - variability coefficient.

Table 13.

Height of the living part of the podetium length of the growth-accumulation period and the mean linear annual growth during this period in the case of Cladonia rangiferina in the PECHORA North according to the subzones and vegetative formations.

1 - Inset 3. 2 - Height of living part of podetium (in cm). 3 - Length of growth-accumulation period (in years). 4 - Mean linear annual growth during the growth-accumulation period (in mm). 5 - Number of samples.

a - Subzones and vegetative formations. b - MALAYA ZEMLYA. c - Western part of BOLSHAYA ZEMLYA. d - Eastern part of BOLSHAYA ZEMLYA. e - Mean. f - MALAYA ZEMLYA. h - Eastern part of BOLSHAYA ZEMLYA. i - Mean. j - Malaya ZEMLYA. k - Western part of BOLSHAYA ZEMLYA. l - Eastern part of BOLSHAYA

ZEMLYA. m - mean. n - MALAYA ZEMLYA. o - Western part of BOLSHAYA ZEMLYA. p - Eastern part of BOLSHAYA ZEMLYA.

II. Subzone of the Northern tundra.

Lichen-tundras.

III. Subzone of the southern tundra. Tundras with birch stands. Hilly tundra bogs.

IV. Subzone of sparse forests of the tundra.

Tundras with birch stands. Hilly tundra bogs. Sparse fir forests. Thinned out fir-forests.

V. Subzone of forests near the tundra.

Tundras with birch stands.

Hilly tundra bogs. Sparse larch-forests. Thinned out fir forests. Ridged-marsh-sedge bogs.

VI. Subzone of the northern taiga.

Thinned out fir-forests. Pine-licken forests.

Pine-sphagnum forests. Ridged marsh-sedge bogs.

VII. Arctic Ural mountains (western slope).

Lichen-mountain tundras.

Birch-stand mountain tundras. Sparse birch forests (mountain).

VIII. Remark: M = mean value; ±M - probable error;

C - variability coefficient.

Cl. sylvatica occupies an intermediate position. The height of the living part of the podetium of this species in the PECHORA North is from 3.5 cm in the tundra to 5 cm in the taiga zone, in the CHUKOTKA tundras it is from 4 -5 cm, in the mean. The first period of existence comprises 10-11 years, in the PECHORA North, 12-13 years on the CHUKOTKA. The living part of the podetium of Cl. rangiferina in the PECHORA North reaches a height from 3 cm in the tundra to 5 cm in the taiga zone, in the tundras of CHUKOTKA - 3-4 cm. The first period of the existence in the PECHORA North is from 8-9 years, on CHUKOTKA - 10-12 years.

Drawing 7 presents a chart that illustrates the course of the accumulation of the living mass by various species of Cladonia. Individual species, in connection with the noted peculiarities, accumulate forage reserves on the pastures in a varying degree. Cl. alpestris forms the largest living mass, Cl. sylvatica forms less and Cl. rangiferina forms still less. On the average the reserve of reindeer moss, if the living part of the podetium is 5 cm high and the soil is covered 100% by lichens comprises in the forest-tundra when Cl. alpestris predominates - 65-70 centners per ha, when Cl. sylvatica predominates - 50-55 centners per ha.

The poor development of Cl. alpestris in the young lichen-covers in which the more rapidly developing Cl. sylvatica and Cl. rangiferina predominate, is explained by its slow growth. In view of the subsequent acceleration of the growth of Cl. alpestris and the accumulation by this species of a larger living mass there occurs an inhibition and even a complete suppression of the other species of lichens and the predominance -on old reindeer-moss pastures- of covers of the heavily developed Cl. alpestris. A number of researchers noticed a long time ago the predominance of Cl. alpestris in the oldest lichen-covers (VASHKEVICH, 1932; RABOTNOV, 1936; IGOSHINA, 1939). However, this fact was not explained or wrongly interpreted as a result of the replacement of the species of lichens, which took place, as it were, under the influence of the increase of the moisture in the soil. Only T.A. RABOTNOV voiced the right supposition regarding the significance of the uneven rate of the growth of the various species.

In a number of areas (The Pechora North, YAMAL) one observes the development of covers of Cl. alpestris only in those places which are seldom or never used as pastures. When the reindeer moss stands are used systematically for pasturing then there occurs a gradual displacement of Cl. alpestris and a development -in its place- of Cl. sylvatica with a participation of Cl.

rangiferina. This is indicated by our observations in the forest-tundra and the tundra of the NENETSKI district and the experience of the reindeer breeders on YAMAL (VASHKEVICH, 1932, p. 93).

The material on the growth-rate of the other species of furticose lichens is extremely scant. Table 15 carries some data on the growth of a number of species in the period of the renewal of the podetium, which were acquired by the "mark" method. Cl. sylvatica, as a standard, is used for comparison.

The data in Table 15, which were obtained by D.M. GLINKA at the NARYAN-MAR experimental station as a result of the observations from 1937 to 1941 and by M.N. AVRAMCHIK at the ANADYR experimental station lead to the following deductions: The amount of the growth of Cl. gracilis is somewhat larger than that of Cl. sylvatica (the considerable acceleration of the growth of Cetr. cucullata was noted by us on -after the grazing of the reindeer- the recovering lichen tundras on the island VAYGACH, on the YAMAL peninsula and on the CHUKOTSKI peninsula). The growth of Cetraria nivalis in the tundra zone is almost 1½ times higher than that of Cl. sylvatica; but in the forest-tundra it decreases considerably. The growth of STEREOCAULON paschale is about the same as that of Cl. sylvatica.

Table 15.

The growth of various species of fruticose lichens. (The mean annual linear growth of the fruticose thallus during the period of the renewal of the podetia).

1 - Area and vegetation. 2 - In millimeters. 3 - In %.

4 - Number of specimens.

a - Lower reaches of the PECHORA river, ombzone of southern tundra, lichen-tundra.

b - In the same place, subzone of the tundra sparse forests, sparse larch forest.

c - Middle reaches of the Anadyr river, subzone of the southern tundra, "KOCHKARNIK" (tussock-covered ground), tundra.

2. Changes in the growth of lichens depending on climatic factors.

The dependence becomes more evident when the indicators of the growth of the lichens is studied in a zonal cross-section. As a rule, the growth of all the species studied is reduced under the more northern conditions, at the same time the height of the living part of the fruticose thallus is curtailed. Table 16 shows our data on the Pechora North for the most typical formations of the tundra and the northern taiga, which reflect the zonal climatic peculiarities to the widest extent.

Table 16

Amount and duration of the growth of the Cladonias in a zonal cross-section in the PECHORA North.

a - zonal vegetation. b - Cl. alpestris. c - Cl. sylvatica. d - Cl. rangiferina.

1 - Growth-rate during the first period (in mm). 2 - Duration of the first period. 3 - Height of the living part of the podetium (in cm). 4 - Number of specimens. 5 - Growth-rate during the first period (in mm). 6 - Duration of the first period. 7 - Height of the living part of the podetium (in cm). 8 - Number of specimens. 9 - Growth-rate during the first period (in mm). 10 - Duration of first period. 11 - Height of the living part of the podetium (in cm). 12 - Number of specimens.

A - Arctic tundras. B - Subarctic tundras. C - Sparse forests in the tundra. D - Sparse forests in the subzone of the forests near the tundra. E - Sparse forests in the subzone of the northern taiga.

We will adduce -for purposes of comparison- data on the basin of the ANADYR river, which are also grouped according to zonal formations (Table 17).

The growth of the Cladonia on CHUKOTKA as well as in the PECHORA North decreases towards the north and the dimensions of the living part of the podetium grow smaller. This law or regularity is confirmed also by a number of other authors on the various areas of the Far North.

The change in the growth in the subzones within the same formations (Table 18) is of interest.

The change in the growth-rate under extreme living conditions is especially radical. In the case of 50 specimens of Cladonia sylvatica collected by us in 1951 at the limit or edge of the vertical distribution or occurrence of vegetation in the mountains of the ANADYR range on the CHUKOTSKI peninsula, the height of the living part -in the mean- was 1.2 cm, the first period of life lasted seven years, the mean linear annual growth for this period was 1.5 mm, the length of the joints in the dead part of the podetium was 2.5 mm (ANDREEV, 1952). The lichens collected in the southern part of the region of their mass-occurrence in the Far East disclosed a growth that was almost as tall as that in the areas of the northern taiga of the European North. According to the data by A.T. REUTT (collections of 1949), on the basis of the measurements made of 2080 specimens of Cladonia sylvatica, that were collected on the larch-covered slopes on the URGAL river (basin of the BUREYA river), in the mean, the height of the living part was 5.7 cm, the first life-period lasted 10.4 years, the mean linear annual growth during this period amounted to 5.5 mm, the length of the joints in the dead part of the podetium -- 7.7 mm. In the adjoining area (basin of the ANGUNYA river) V.B. SOCHAVA points out a height of 6.7 cm and a period of 15 years to reach the full growth for Cl. sylvatica (1934, p. 216).

The adduced data show, without doubt, that the growth-rate of the fruticose lichens decreases towards the north and reacts very readily to a change in the climatic factors in the various subzones.

B.N. GORODKOV - along time ago- mentioned the change in the growth in a zonal cross-section. At present his supposition has been fully confirmed by an abundant material (1926, p. 11).

Simultaneously with a slowing down in the growth rate there is a reduction in the height of the living part of the podetium.

N I L

A number of researchers has pointed out repeatedly the retarded or inhibited growth of the fruticose lichens on the islands and the coast of the Arctic Ocean. The first explanation of this phenomenon was given by N.I. KUZNETSOV, who wrote that "the facts show directly how severely the fruticose lichens are affected by the cold: They, like the highest (order) of the Arctic plants, are of an insignificant height, are flattened to the ground and thus adept themselves to the severe climate" (1886, p. 262). A.A. ELENKIN also observed the "reduction of the lichen forma flora" (in the sense of the reduction of the dimensions of individual plants) on the Arctic coast of Siberia (1909, p. 3).

Table 16.

Changes in the growth of Cladonia sylvatica on the PECHORA North in the subzones within the limits of the same formations.

(Mean annual linear growth of the podetium during the growth-accumulation period in mm, in brackets -the number of specimens).
1 - Subzones. 2 - Lichen-tundra (BOLSHEZEMELSKAYA tundra).
3 - Lichen-tundra with birch stands - (BOLSHEZEMELSKAYA tundra).
4 - Fir-lichen sparse growth forest (MALOZEMELSKAYA tundra).
a - Of Arctic tundra. b - Of Northern tundra. c - Of the southern tundra. d - Of the sparse forests in the tundra. e - Of the forests near the tundra.

Our researches indicate a regular reduction in the height- according to the subzones- in the case of all the species studied. In connection with this it is important to note that the duration of the first period of the existence changes very littlein a zonal cross-section. Therefore the reduction in the height of the living part of the podetium and the reduction of the reserve of the feed mass of the lichens under more northerly conditions result from a slowing down in the growth-rate. This fact is of importance in establishing a proper pasture-rotation in reindeer breeding.

It seems that the shortening -towards the north- of the period that is free of snow and frost to which fall, according to the researches by D.M. GLINKA and A.S. ELENKIN, not less than

80% of the entire annual growth is of decisive significance in slowing down the growth-rate. From a certain moment, so it seems, there is also apparent a lowering of the temperature of the growing period, which slows down the processes of metabolism. It seems that this cause becomes apparent only in the subzone of the Arctic tundra, where the drop in the growth is not proportional to the shortening of the period that is free of snow and frost. The growth of the lichens as established by a number of researchers furthermore depends to a considerable degree upon the light regime and the dampness or humidity of the thallus (GORODKOV, 1936, pp. 92-94). The latter factor is of a zonal nature. The lichens will grow only if the thallus has been sufficiently moistened and "softened" and will stop growing when the thallus becomes dry and unable to stretch and extend. The moistening of the tahllus depends upon the relative dampness or humidity of the air-layer near the ground and the dampness of the surface of the soil. When the summer is warmer a larger number of dry days interrupts the growth of the lichens. In view of this the amount of the growth as one moves from the more northerly subzones to the southern ones does not increase as rapidly as could be expected seeing that the vegetation period grows longer. One should assume that in view of the cause just noted further south, beyond the confines of the territory studied by us, the growth-rate will hardly produce a larger amount than in the far North and in a number of cases it will be considerably smaller. This circumstance lowers the competitive capacity of the lichens and is one of the important causes which determine the southern boundary of the mass-occurrence of the fruticose lichens.

The differences in the growth in areas with a varying degree in the continentality
~~in establishment~~ of the climate are due to the same cause.

By means of our material on the Pechora North it is possible to establish a drop in the growth from west to east which is related to the growing continentality of the climate. According to the material adduced in Table 19 in which the data on all our collections from various subzones and formations are summarized,

a drop or reduction in growth from west to east in the direction of the growing continentality of the climate is clearly indicated.

Table 19.

Change in the growth of the Cladonias depending upon the degree of the continentality of the climate.

(Mean annual linear growth of the podetium during the growth-accumulation period in mm; in brackets the number of specimens).

a - Species of Cladonia. b - Malozemelskaya tundra.

c - Western part of the BOLSHEZEMELSKAYA tundra.

d - Eastern part of the BOLSHEZEMELSKAYA tundra.

Table 19 shows the mean values according to various formations. However, this same regularity is well manifested when comparing the growth of plants from like or uniform formations within the confines of one subzone. For instance, the growth of Cl. sylvatica in the subzone of the sparse forests near the tundra on the hills of a flat-hill bog in the MALOZEMELSKAYA tundra is 5.8 mm, in the western part of the BOLSHEZEMELSKAYA tundra it is 3.0 mm, in the eastern part of the Bolshezemelskaya tundra it is 2.5 mm. The growth-increase of the same species in the same subzone in the tundra-lichen birch stands in the MALOZEMELSKAYA tundra amounts to 3.7 mm, in the BOLSHEZEMELSKAYA tundra to 3.3 mm. A similar regularity is explained by the fact that the periods of warm weather in summer when the growth of the lichens stops, are relatively rare in the MALOZEMELSKAYA tundra, are somewhat more frequent in the eastern part of the BOLSHEZEMELSKAYA tundra. In the same direction there is a drop in the relative humidity of the air, in the frequence of frogs and of precipitation during the summer months.

A comparison of the growth in various areas of the Far North also confirms the dependence of the growth upon the nature of the weather during the summer months (Table 20).

Table 20

Change in the growth of Dicranum sylvatica in the tundra sparse forests in the various areas of the Far North. (Mean annual linear growth of the podetium during the growth-accumulation period in mm; the number of specimens is in brackets)

1. KOLA peninsula, KHIBINY river, middle reaches .....
2. PECHORA river, left bank of the lower reaches....
3. MALY YAMAL peninsula, northern part of the basin of the NADYM river.
4. KAMCHATKA, basin of the TIGIL river.

The fastest growth-rate, as should be expected, was reported from the west coast of northern KAMCHATKA with its damp and cold summer. In the central part of the KOLA peninsula, between the OBSKAYA and TALOVSKAYA guby (gubas=bright. Tr.), in the lower reaches of the Pechora river and on the MALY YAMAL peninsula the growth was considerably less than there should have been in relation to the shorter and drier summer that is peculiar to these areas. The larger size of the fruticose lichens observed by ALBERT on the St. Laurent island in comparison with the arctic coast of Siberia (1887) should be ascribed in the first place, to the damper maritime climate in the area of the BERING strait.

3. Changes in the growth of lichens depending upon the nature of the vegetation.

For the purpose of ascertaining the nature of the changes in the growth-increment of lichens in individual vegetative formations we will study the influence, firstly, of the upper stories in plant communities, secondly, the water-logging of the soil and, thirdly, the degree of the homogeneity of the lichen-cover.

In the copse-formations the lichens grew on the glades between the bushes. In view of this they are only slightly affected by shading. The effect of the protection of the bushes upon the growth of the lichens is positive. The data adduced in Table 21 indicate a faster growth-rate of the lichens in the

copse formations in comparison with the copse -less formations that in nature are closely related to them. The difference in the increment is greater in that case when the effect of the copses is greater (in the thickets of ground cedar). This is the result of a change in the micro-climate in the thickets of copse, which is manifested in reducing the force of the wind, by increasing the relative humidity of the air, by moistening the surface of the soil as well as by retaining the snow, which protects the lichens from quick freezing and enables them to grow under the snow for some time.

Table 15.

Changes in the increment of Cladonia depending upon the development of the copse-story (Mean annual linear increment of the podetium during the increment-accumulation period in mm; the number of specimens in brackets).

1 - species of Cladonia. 2 - Pechora North (subzone of the southern tundra). 3 - Northern Kamchatka (belt of the cedar copse). a - birch-stand tundra; b - lichen tundra; c - cedar copse; d - mountain tundra.----

The difference in the growth-rate in most cases is related to an increase in the height of the podetium in the event of the constancy of the duration of the increment-accumulation period.

An arboreal story affects the lichens in a similar way. The lichens, which, in considerable quantities, grow in the open places (in the tundra-component) in sparse forests and in the lighted places of thin forests, disclose a higher growth-rate than in the same zonal conditions in communities that are deprived of the arboreal and copse story. The positive influence of the arboreal story upon the micro-climate is manifested in the same way as in the influence of the copse story.

The existing opinion about the inhibiting effect of the arboreal and copse story upon the growth or development of the lichens must be defined. The fact is that in the denser copse-

thickets and under a more close forest-canopy the fruticose lichens do not grow in considerable quantities. In most cases, however, the cause is not the inhibiting effect of the top story that reduces the hours of light but the competition of the abundantly growing shade-requiring mosses, brushes and grasses. ~~Single~~ Single specimens of Cladonias, that survived in such places, disclose a rather intensive increment and a considerable height of the podetium.

This deduction is fully confirmed by the experiments of V... KOV KIN., who established on a test plot in a sparse fir-stand on the PONOY river (Murmansk oblast), that of the three versions on the intensity of light (1 - full light or illumination, 2 - slight shading with a white gauze slip and 3 - heavy shading by means of a dark gauze slip and spruce boughs (?)) the largest increment was recorded under conditions of the heaviest shading, the smallest under full light. We will study the effect of water-logged soil upon the change in the increment of the Cladonias.

The data in Table 22 do not show a definite and great difference between the growth-rate of the lichens on swamps and those growing under the same zonal conditions in non-swamp communities. There is a tendency towards an increase in the increment on bogs, but it is not very strong. This must be related to the fact that on bogs the lichens grow on the positive forms of the microrelief; on the surface of turf or peat ~~mass~~ knolls, on turf or peat ridges and on tussocks. The edaphic conditions for the lichens here differ little from the tundras with the turf or peaty or simply gley soils. A difference can arise only on the larger swamp-massives as a result of the heightened humidity of the air.

Table 22.

Increment of the Cladonias on bogs or swamps. (Mean annual increment of the podetium during the increment-accumulation period in mm; in brackets, the number of specimens.)

1 - Species of Cladonia. 2 - Pechora North. 3 - KOLA peninsula; 4 - northern KAMCHATKA.

a - knolly swamps; b - lichen-tundra; c - ridged-marsh sedge swamps; d - lichen-forest; e - swamps; f - tundra; g - swamps; h - tundra.

In order to record the growth-rate of the Cladonias, in dependence upon the specific composition of the lichen-cover, samples were collected within the confines of one and the same community, but in different associations. With a cover of one species of Cladonias (above 90% participation by one species) and in mixed ones with about an equal participation of Cl. alpestris, Cl. sylvatica and Cl. rangiferina.

Table 23.

Increment of the Cladonias in mixed and pure lichen covers in the PECHORA North. (Mean annual increment of the podetium during the increment-accumulation in mm; number of specimens, 20 everywhere.)

1	2		3		4	
	a	b	a	b	a	b
Cl. alpestris	3.2	2.8	2.5	2.2	2.0	1.8
Cl. rangiferina	2.8	1.6	2.2	1.3	1.8	1.0

1 - Species of Cladonias. 2 - Lichen-tundra. 3 - copse tundra. 4 - Pine-lichen forest.

a - pure cover; b - mixed cover.

In every case (Table 23) a faster growth-rate is observed in the pure covers. It is characteristic that in the case of Cl. alpestris the difference was less than in the case of Cl. rangiferina. This indicates a less severe inhibition of Cl. alpestris in mixed covers and its greater significance as a community-builder. The adduced data correspond to the opinion regarding the mutual"favorableness" of the plants of one species in the event of growing together (LYSENKO, 1952, II).

V. Methods for regulating the increment of forage lichens.

The view that it is extraordinarily difficult or even impossible to influence the growth of lichens has become rooted in science. G.I. TANFILYEV assumed that "it is not within the power of man to accelerate its (i.e. of reindeer moss. V.A.) growth" (1892, p. 30). Even recent literature contains no indications that it is possible to affect the growth of lichens

to any extent. All the researchers, who studied the question of the acceleration of the growth of lichens, directed their efforts at developing methods to establish the amounts or values of the increment. However, the question of accelerating the increment of the lichens by certain measures has not yet been studied.

Nevertheless, this problem is posed by the national economy of the Far North. Upon its solution depend -in a number of areas- to a certain extent the development and productivity of reindeer breeding in the North.

The reindeer-moss grazing grounds that are of greatest importance to reindeer-breeding were greatly exhausted in some places. This was due to the predatory use of them, for many decades, in pre-socialist reindeer breeding. Due to the improper use the reserves of reindeer moss, on the larger part of the grazing area, were greatly reduced and the increment here proceeds very slowly at the moment. Considerable areas of the reindeer grazing grounds are threatened with complete exhaustion.

At the moment under the conditions of collective farming we have chances to change the nature of the reindeer-pastures towards increasing their productivity.

One must diffirentiate between the two directions or tendencies in the work to increase the productivity of the reindeer pastures: Firstly, it is necessary to increase to a maximum the area under reindeer-moss and grasses, that remain green in winter, at the cost of reducing the area under green mosses and other plants, which are unimportant as forage; secondly, conditions must be created for a maximal rapid growth of reindeer-moss and the accumulation on the pastures, in a short time, of a large reserve of forage.

The work of the second tendency is of greatest significance and it must be based upon the regulation of the increment of the forage lichens.

The methods for regulating the increment of the lichens must be divided into two groups: The first, methods for a proper use of the reindeer moss fodder, which would take into consideration the most remote consequences of the effect of the reindeer upon the lichens. These methods must be based upon the establishment of a definite regime for the utilization of the grazing grounds. This regime must ensure the most rapid sprouting of the reindeer moss browsed upon and prevent the perishing of the reindeer moss reserves by decomposition. The second, methods for stimulating the growth of the reindeer moss by the use of special agricultural-engineering measures.

1. Acceleration of the increment of the lichens by regulating the height at which they are bitten off by the reindeer and the periodicity of their utilization.

The system for a proper use of the reindeer-moss pastures must be built upon a consideration for the periods of time required for a restoration or renewal of the consumed reindeer-moss and the conditions that ensure its complete and rapid sprouting.

By means of a proper organization of the grazing or pasturing on a large scope the periods of time and the height at which the reindeer moss is bitten off or cropped can be changed. The task is that the pastures should be used at such intervals of time which would ensure a complete sprouting of the reindeer-moss and to pasture them in such a way as to ensure the sprouting of the remaining part of the podetia in the shortest possible time.

On the basis of the above researches one can establish certain best intervals and determine the height of cropping. By bearing in mind the peculiarities of the growth of the podetium during certain periods of its existence it should be assumed that the most advantageous period, in an economical sense, for the use of

10-15 years

reindeer moss is the beginning of the second period, the restoration or renewal of the podetium. It is at this time that the largest forage reserves are accumulated on the pastures. During the subsequent course of the development, as mentioned above, the reserves hardly increase; but in some years, depending on the changes in the external conditions, it is subjected to slight fluctuations.

A study of the dynamics of the accumulation of the living mass of reindeer moss indicates that in some cases(for instance in covers of Cl. alpestris)due to the expansion of the lateral branches of the podetium the increment or increase in the forage mass or bulk continues during the first years of the second life-period. In those cases when this increment yields a considerable addition to the general forage reserves, the time of the utilization can be shifted for several years (up to 2-3 years) after the main bulk of the podetia has entered upon the second period of their existence. However, one should not wait for the full completion of the accumulation of the forage mass, seeing that in connection with the dying-off process, the accumulation process during the last years is greatly slowed down and does not yield an essential addition to the general reserves. The increment during this period can be disregarded.

Table 24, on the basis of the material of the researches dealt with above, carries the intervals of times required for restoring the forage reserves in the event that the podetium was cropped at the mean heights (at 3/4-2/3 of its height).

Table 24.

Intervals for restoring the forage reserves of reindeer moss. 1 - Predominant species in a reindeer-moss cover. 2 - Intervals of time required for restoring the forage reserves (in years) a - Average. b - Shortest. c - Longest.

In each concrete case the time needed for restoring the forage reserves, should be ascertained on the basis of the predominant age of the living part of the podetia that entered upon the second period of their existence, which can be ascertained easily by means of the methods mentioned above.

If reindeer moss, which has not yet completed its first period, is used then the amount of the increment is reduced considerably. By using the data on the increment of the mass of Cladonia sylvatica, adduced in Table 7, it is possible to determine to what an extent the amount of the increment will be reduced in the event of a premature use of the reindeer-moss pasture. If the reserves of 15-year old reindeer-moss (meant is the age of the living part of the podetium), which has entered upon the second period of the existence of the podetia is accepted as 100% then at the age of 12-13 years it comprises only 80%, at 10-11 years - 60%, at 8-9 years-40%, at 6-7 years 26%. Therefore, regarding 15-year old reindeer-moss fit for utilization we see that the mean increment of the mass, in this case, comprises 6.7% (100:15). If the reindeer-moss is used two years before it has reached maturity then we by gaining two years for shortening its restoration-period lose 20% of the reserves. In connection with this the mean increment of the mass per year will comprise not 6.7%, but 6.1% (100:13). If the reindeer moss is used 4 years prior to reaching maturity there will be a shortage of 40% of the reserves and the mean annual increment will comprise 5.4%. If the reindeer moss is used 6 years prior to reaching maturity the annual increment will comprise 4.4%. If it is used 8 years ahead of maturity --3.7%. This shows that as a result of the use of "unmature" or "unripe" reindeer-moss the forage reserves and the bulk of the annual increment of reindeer-moss is reduced considerably.

In the reindeer-moss stands comprised of Cl. alpestris the reduction of the increment in the event of premature pasturing is still more pronounced.

In the event of a haphazard utilization of the reindeer-moss pastures the absence of any kind of periodicity in the pasturing-dates leads to a radical reduction of the increment on the best pastures that are used more frequently and more intensively. At the same time part of the reindeer-moss stands is "visited" infrequently or is used not at all.

The occurrence of overripe reindeer-moss stands, which is quite understandable, should be regarded as an undesirable phenomenon. A lengthening of the period of the restoration (or growth) of reindeer-moss, in this case, will not be accompanied by an increase in the forage reserves; for instead of that there will take place an accumulation of lichen-peat.

In the infrequently used lichen-covers, due to the reason mentioned, the increment of the fruticose lichens is slowed down in comparison with the covers that are regularly used and lack a layer of the dead mass.

Thus, the greatest acceleration in the increment of fruticose lichens can be achieved only if they are utilized systematically and at the right time.

The data adduced in Table 25 can be used in determining when the reindeer-moss stands are fit for pasturing.

This table shows, on the basis of data resulting from numerous observations, partly reported in section 4 of this work, the mean dimensions of the living part of a "ripe" podetium and its age. The podetia, which have attained the size and the age mentioned in the table can be regarded, for practical purposes, as having completed the first period of its development and as fully "mature" for pasturing.

Table 25.

Mean dimensions of the living part of the podetium of Cladonias fit for pasturing and its age.

(Data for a practical application).

1 - Vegetation. 2 - Species of Cladonia. 3 - Pechora North.

4 - CHUKOTSKI "OKRUG" (district).

5 - KORYAKSKI "OKRUG" (district).

a - height (in cm); b - age.

I. Arctic and highland tundras.

II. Subarctic tundras.

III. Sparse tundra forests and large-copse thickets.

IV. Sparse forests near the tundras.

The second most important condition for accelerating the increments of reindeer-mosses is the "organization of the superficial cropping of the podetia." It was stated above, that, on the basis of researches, it was established that the closer the podetium is cropped the slower is its restoration and the slower, on the average, is the rate of its annual increment.

Table 26 shows that the size of the annual increment of reindeer moss, if "the superficial cropping of the podetia is organized", can be increased more than twice in comparison with close cropping, which is observed very often on the pastures.

Table 26.

Mean bulk or mass of the annual increment of the reindeer moss at a varying height of cropping the podetium.

(Applies to Cladonia sylvatica).

1 - Nature of cropping the podetium. 2 - Cropping of the podetium. 3 - The usable part of the forage reserve (in %). 4 - Time required for restoring the used mass (in years). 5 - Mean mass of the annual increment of reindeer moss.

a - in % of reserves; b - in comparison with close cropping.

I. Close cropping. II. Medium cropping. III. Superficial cropping.

Thus there exist good reasons for accelerating the increment of reindeer moss by means of a "rational" organization of its utilization.

In order to put the existing possibilities to practical use one must study the "concrete" conditions for utilizing the pastures.

Similar work was carried out in the various areas of reindeer-breeding by a small group of geobotanists and participating animal breeders (Russian = zootechnicians. Tr.). The following participated in this work from 1935-1951: In the Murmansk oblast - A.S. SALAZKIN, A.V. KOVALKINA, A.A. POKROVSKI; in the NENETSKI national district - D.M. GLINKA, A.V. VALINGER, N.K. GERASIMOVA, VOLOGDIN and others; in the KOMI A.S.S.R. - P.A. BYKOV and CHERNYSHOV; in the YAMALO-NENETSKI district - V.M. SDOBNIKOV, I.D. KILDYUSHEVSKI, M.N. AVRAMCHIK and others; in the KHANTY-MANSIYSKI district - K.N. IGOSHINA and E.F. FLOROVSKAYA; in the ANADYR area - M.N. AVRAMCHIK. The work was carried out under the general supervision of the author. The research carried out by the author pertains to the NENETSKI and YAMALO-NENETSKI districts. Similar work was carried out, in keeping with our methods, in 1951 under the direction of A.T. REUTT by eight geobotanists of the CHUKOTSK expedition of the MSKH of the R.S.F.S.R. in the MARKOVSKI, ANADYRSKI and CHUKOTSKI rayons (administrative units. Tr.) of the CHUKOTSKI national district and in 1952 under the direction of N.I. TEMNOEV by six geobotanists of the MEZHOBLASTNAYA (Inter-provincial) expedition of the MSKH of the R.S.F.S.R. in the northern "rayons" of the KOMI A.S.S.R. The results of all this work represent a large independent theme or topic. For this reason we will here limit ourselves to a brief statement of the methods and of the basic deductions which have a direct bearing upon the problem.

In 1935, we, together with V.M. SDOBNIKOV, used the method of the study of the "TROPY" on the YAMAL and OBSKO-TAZOVSKI peninsulas. This method, in a pridditive form, was first applied by V.N. VASILYEV in 1933 on the ANADYR river (see VASILYEV, 1936). At the same time, the feeding of the reindeer in a feeding herd was observed by round the clock, (day and night) observations. This method, refined or improved, was used as the basis of all further researches.

By "TROPA" or "KOPISH" (an area to be pastured by reindeer. Tr.) the reindeer-breeders mean the area of the pastures used in pasturing. The study of a "TROPA" consists in a survey of it on a scale of 1:10 000 - 1: 25000, with an indication of the outer bounds of the "TROPA", the types of pastures and the forage reserves that occur on it, the extent to which the various parts of the pasture area and of the forage reserves have been utilized. At the time of the year when snow covers the ground, the depth and compactness of the snow-cover (blanked) and the size of the dug-up places where the feed was consumed. The round the clock observations in a feeding herd are to establish the following: The order in which the pastures are changed within a 24-hour period; the way in which the feed is consumed; the distribution of the time between feeding, resting and migrations; correlation of the time spent in consuming the various species of feeds; methods used by the herder or keeper to regulate the grazing, etc. This work is at times accompanied by an examination of the content of the rumen of a reindeer (to establish the quantitative correlations between the species of the feeds consumed) and an analysis of the plant remains in the holes, i.e. in the places were the feed was consumed in order to establish the used or consumed, damaged and remaining feed reserves on the pasture.

In a similar way, during the various seasons of the year, several hundred diurnal "TROPY" were examined in various areas.

As a result it was established that the reindeer-moss fodders are utilized extraordinarily unevenly. The snow-blanket is quite an obstacle to reaching them. Loose snow with a compactness of about 0.2 can be dug up to a depth of 1.5-2m; as the snow grows more compact the depth of the "diggings" decreases. Snow with a compactness of 0.3 is accessible only to the strongest reindeer. The pastures which are covered by snow ~~xith~~ with a compactness above 0.3 cannot be utilized in a practical sense. The easier the feed can be reached the greater is the area, within the confines of a "tropa" on which the feed is consumed.

However, in distinction from other species of domestic animals, the reindeer never consume all the feed. Usually, from 15 to 50% of the forage reserves in an area are consumed.

On the average during the winter season, 20 to 25% on the pastures in the tundra, in the forest-tundra, 30-35%; in the northern part of the taiga zone, 25-30% of the forage reserves are dug out. (Andreev, 1951)

The extent of the consumption, i.e. the height at which the feeds are cropped depends also upon the degree of the accessibility of the pastures. In the less accessible pastures in the places where the snow is dug up the fodders are consumed to a greater extent. On pastures with a light snow blanket the fodder are cropped superficially most of the time.

The size of the herd, the length of the intervals when pastured and the pasturing technics with regard to reindeer exert a tremendous influence upon the nature of the utilization of the pastures. It is these factors, that can be controlled, that are of greatest interest.

When the herd is large (two to three thousand head) the reindeer are usually crowded and consume the feed more completely in comparison with smaller herds. When the size of the herd is reduced there results a reduction of the area of the cropping of the feeds within a "TROPA" and the feeds are consumed to a lesser extent. At an early utilization (at the beginning of winter, when the snow is not deep) the consumption of the feed is more superficial; later on (the second half of winter, when the snow is deeper and packed), the consumption is more extensive.

A more complete and uniform use of the pastures can be achieved by a skilful rotation within the season, as it were, of the pastures during the time of the year, when snow covers the ground.

In that way almost all of the fodder reserves can be drawn into the scheme and utilized. For these reasons, the leading farms make use of only those places in early winter that later, due to the snow-blanket, become inaccessible. ~~of the~~ ~~re~~

Of the more accessible pastures first of all those are utilized that are poorer with regard to reserves, seeing that the richest pastures are kept for the hardest time of the year in regard to getting feed, the end of winter. By adjusting the size of the herd to the sizes of the feeding areas it is possible to keep fewer head of reindeer on a certain area. This will lead, within the scope of a "tropa" to a reduction of the area of the cropping of the feed and the extent of their consumption is also reduced. According to the data by D.M. GLINKA the smallest "isolated" section of reindeer-pastures in the fir-birch lichens sparse forests is an area of 20 ha for 500 head for a 24-hour period, for a herd of 1000 head, 105 ha. In the tundra-lichen pastures the corresponding smallest values of the isolated values comprise 10, 20, 30, 40 and 50 ha (ANDREYEV, 1951).

Sections of smaller sizes are not fit for pasturing; for when a herd is feeding on disproportionately small sections the animals are crowded. This has a harmful effect upon the pastures as well as upon the bodily condition of the reindeer. The experienced reindeer breeders and senior herders of the NENETSKI national district, namely, I.P. KANEV, V.S. SEMYASHKIN, M.P. VOKUEV, S.F. KANEV and others, maintain that, when the reindeer are crowded the animals crop the reindeer moss very closely, almost at the base; this is the foremost cause for the deterioration of the reindeer-moss pastures.

It must also be borne in mind that a herd not exceeding 1.2-1.5 thousand head, as experience shows, can be handled with relative ease, by the herder on duty under the conditions of the forest-tundra. With a herd of this size the required efficiency which makes it possible, at the right time, to move or drive the reindeer from the utilized sections of the pastures to fresh ones is achieved. In the event of a herd of a larger size the handling of it on the pastures is considerably complicated. This leads, in some places, to excessively crowded grazing and to an extreme consumption of the reindeer moss where the snow has been dug up.

In order to provide, in the best way, the reindeer with lichens and green forage the experienced herders do not permit the reindeer to remain, for any length of time, in one place and compel them to dig up the snow and to get fresh feed on a larger area. As soon as the herder perceives that the reindeer on a given section begin to "paw" the snow less vigorously and to feed for a second time upon the feed in holes dug previously he moves the herd to a new section of a pasture not yet touched.

The digging up of the snow and the consumption of the feed is stimulated by providing the reindeer with table salt at the beginning of the second half of winter (picture 15)

The method for utilizing the pasture-forage depends upon the condition of the reindeer, to a considerable extent. Undernourished reindeer, that grew feeble towards the end of winter, cannot perform "the work of digging up the snow" which they could do when in better health. More and more energy is used in digging up the snow as winter drags on. According to the data by S.N. ALEKSANDROV the expenditure of energy in snow-digging towards the end of winter, in comparison with the first half of winter, increases by 35% (GULCHAK, 1950).

Towards the end of winter, even on the good pastures, it is necessary to curtail the "digging" area and to tolerate a more complete consumption of the feed in the "LUNKI" (holes made by the reindeer. Tr.) At this time, the reindeer are reluctant to dig up the snow there appear enfeebled animals, which do not dig up the snow but feed upon the left-overs in the holes that were dug by the stronger animals. The herders check the attempts of the more active animals, to move to fresh pastures, bearing in mind the fact that it would be difficult for the entire herd to dig up large areas and for the purpose of maintaining the bodily condition of the herd the dug-up forage reserves must be utilized more fully. The dug-up area (or more exactly the area on which the forage has been consumed) comprises, in the mean, per one reindeer in the middle of winter 70-100 m^2, towards the end of winter only 50-60 m^2.

What has been said declares with one voice that the practical problem of regulating the increment of the fruticose lichens can be solved by changing the dates and the height of cropping. However, one must consider the "concrete" conditions for using the pastures.

This problem can be solved by a proper pasture-rotation, by organizing a proper pasture-rotation within the season, by introducing quiet less crowded grazing and a timely transfer of the reindeer from the used pastures to fresh ones.

We will deal briefly with each of these conditions.

The scientific works of the following authors deal with ~~devising~~ devising a proper pasture-rotation (in the interest of reindeer breeding, namely: K.I. IGOSHIN. (IGOSHINA and FLOROVSKAYA, 1939), V.N. MUREEV (1940) as well as A.S.SHUMKIN, D.M. GLINKA, A.V. VALINGER and M.N. AVRAMCHIK. Unfortunately these works have remained unpublished.

As a result of these works it became evident that the pasture-rotation in reindeer breeding on reindeer moss stands differs in a peculiar way from the pasture-rotation in other branches of animal husbandry. When establishing a pasture-rotating system one must, first of all, take into consideration the peculiarities of the restoration of the feed reserves of reindeer-moss.

In distinction from alternating the pastures, which was caused by the need for changing the places of seasonal grazing the pasture-rotation is an alternation caused by the necessity to preserve the feed reserves and to create the conditions for the most rapid restoration or replenishment of the forage consumed.

At the common existing order for utilizing the winter pastures, as indicated above, the reindeer moss is cropped on an area that comprises in most cases from 20 to 30% of the entire area that is covered with reindeer moss. In the utilized places the restoration of the reindeer moss, on an average, takes place during 10-13 years (see Table 24). It can be foreseen easily, what will

in the event that one and the same places are utilized every year. If during each "visit" the places with the intact reindeer-moss reserves will be dug up the entire reindeer-moss area will be utilized during 3-5 "visits".

Later on the reindeer will be compelled to use the reindeer-moss in those places where the feed reserves have not yet been restored or replenished. In this way, in the course of a few years the reindeer-moss pastures can be rendered completely useless and must be excluded from utilization for many years.

When a proper pasture-rotation is lacking usually the best sections of the pastures, that are most accessible and convenient for utilization are grazed to the point of complete exhaustion. In connection with this the total feed reserves, as a result of cropping the reindeer-moss below the base of the podetium and the cropping of young still "unripe" reindeer-moss stands, are greatly reduced, which to a still greater extent retards the increment of the reindeer-moss and lengthens considerably the interval of time required for the restoration of the feed reserves of reindeer-moss. In order to prevent this it is imperative that for a period of 10-13 years, during which the total reserves of the reindeer moss can be restored, the pastures be "visited" no more than 3-5 times. The reindeer-breeders know very well that in winter time after grazing there is formed on the "tropa" a firm and dirty snow-crust and that one and the same pasture cannot be pastured more than once during the winter season. Therefore, 3-5. "visits" to one and the same section of the pastures over a period of 10-13 years can be tolerated in 3-5 years. This shows that one year of "visits" should be matched by 2-3 years of rest.

Thus one rotation must consist, in the mean, of 3-4 years (one year of utilization and 2-3 years of rest). The directions in literature that advocate that a rotation should last for 10-15 and even 15-30 years (for instance, PAVLOV, 1948, p. 61) are based on the wrong initial data. The materialization of similar

directions can only inflict extraordinary harm upon the "pasture-economy" and discredit the entire idea of pasture-rotation.

Views or opinions about the economical advisability of short-term pasture-rotations were voiced by V.B. SOCHAVA (1933), B.N. GOROBKOV (1936, p. 113), V.N. VASILYEV (1936, p. 97), although neither of the authors substantiated his views.

Depending upon the natural and economic conditions the pasture-rotations can vary in duration.

Pasture-rotation is a necessary measure for regulating the increment-rate of the reindeer-moss. By means of it uniformity and periodicity in the dates for the cropping of the lichens are achieved. The lack of pasture-rotation is a display of elementarity, in the utilization of the natural resources, a predatory exploitation of them, which results in a general reduction of the productivity of the pastures. The introduction of pasture-rotation is a planned utilization of the natural resources, it is a necessary condition to increase the productivity of the pastures and the first step in the transformation of the vegetative cover of the pastures.

By means of a "concrete" example we will examine the increment-rate of the reindeer-moss when pasture-rotation is in effect. A section of the fir or spruce-birch sparse forest in the PECHORA forest-tundra had been utilized. The density of the growth is 0.2, the height of the trees is up to 8-10 m, of them birch comprise 60%, fir or spruce 90%. The reindeer-moss cover extends over 75% of the area. The height of the living part of the podetium is 4 cm. Cladonia sylvatica, which is in the initial stage of the period of the renewal of the podetium, predominates. The first period of the increment-accumulation lasts 9-10 years. The pastures were used every third year, each time in January, when the snow was 35 to 60 cm deep. The herd of 1200 head was handled by experienced herders, who knew the territory of the pastures well.

Drawing 8 presents a "cartogram" of the diggings in the snow for feeds during three successive "visits" to the pastures. A small section of the pastures was "mapped out". The "lunki" (holes. Tr.) measure 1-3m in diameter. At each visit the reindeer-moss was cropped on about one-third of the area covered by it. During the three visits almost the entire surface of the reindeer-moss cover was cropped.

Only small inaccessible places were not utilized. In connection with this there occurred a certain overlapping of the diggings. The extent of the overlapping fluctuated within the range of 20 to 40%. It is characteristic that reindeer dig only where there is forage. The suggestion by A. MIDDENDORF that the reindeer smell the presence of reindeer moss through the snow-blanket (1869, p. 505) is confirmed by reindeer-keepers and by a number of contemporary researchers (AVRAMCHIK, 1939, p. 54). As a rule the reindeer, first of all, dig up in a pasture the places with a large reserve of feed, then, the places with browsed over or "unripe" reindeer-moss and almost never dig where there is no reindeer-moss or the forage grasses that stay green under the snow are lacking.

The size and shape of the diggings change in the different years (drawing 8). In the example adduced by us sharply outlined, shallow, roundish holes made in the deeper and packed snow-blanket predominated during the first visit.

During the second "visit" the places of the diggings were less definite in outline, encompassed larger areas. This was related to the smaller thickness of the snow cover or blanket and the easier "raking" of the snow. The diggings of the third "visit" occupy an intermediate position. As a result of the grazing the reindeer moss was cropped, in the mean, at a height of about 1.5 cm and 70-80% of the entire reserves were removed from the hole (Russian: lunka. Tr.).

Drawing 8. Places where a herd dug for reindeer-moss during three visits on a section of a pasture (fir-birch sparse forest

with reindeer moss in the forest-tundra of the NENETSKI district).

1 - first visit; 2 - second visit; 3 - third visit.

The restoration of the reindeer-moss on the pastured places takes place in a two fold way. Firstly, during 1-2 years the pulled out and broken-off podetia and their parts recover. Frequently the broken off bushes of reindeer-moss attach themselves not to the surface of the soil but to the other bushes that are still in touch with the soil. At times one can observe bushes of various species and even genera that had grown together: Cladonia sylvatica and Cetraria cucullata, Cl. alpestris and Cl. rangiferina and other combinations, which are of great interest with regard to the possibility of forming vegetative hybrids with regard to lichens. The plants are accustomed or acclimatized in the second year after the grazing and the accustomed plants begin to produce the normal increment. The acclimatized bushes and their parts comprise, in the mean, from 5 to 10% of the entire reserves of reindeer-moss. Thus this way of restoration of the fodder reserves is of great importance.

Secondly, there occurs the sprouting of the cropped bushes. At a cropping height of 1.5 cm the restoration of the living part to a height of 4 cm is achieved, bearing in mind the dying off of the remaining "stump" with a height of 1.5 cm, in 9-10 years. The increment-rate, in general, is characterized by the following values: During the first year after the cropping a height of 1.6 cm is reached, during the second year, 1.7 cm; during the third year, 1.8 cm; during the fourth year, 2.0 cm; during the fifth year, 2.2 cm; during the sixth year, 2.5 cm; during the seventh year, 2.9 cm; during the eighth year, 3.4 cm; during the ninth year, 4.0 cm.

Towards the time of the fourth visit to this section of the pasture by a herd of reindeer, which according to the order of the pasture-rotation should take place 9 years after the first visit the fodder reserves on the places that were utilized

during the first visit will be restored already. In view of the partial overlapping of the diggings and the partial use of "unripe" reindeer-moss the restored reindeer-moss cannot yield the original reserve. This shortage should be taken into consideration when determining the capacity of the pastures and to allow periodically some additional time to restore the "accumulated" shortage or deficiency.

Thus pasture-rotation makes it possible to lead the course of the increment or reindeer-moss into a definite system, which safeguards the restoration of the fodder reserves of reindeer-moss on an area that is needed for a herd when it reaches a pasture. Instead of the random and chaotic distribution of the places with reindeer-mosses that have been pastured to a varying degree (from those cropped closely to those browsed upon only superficially), which alternate with sections covered with unused overripe reindeer-moss, in the event of pasture-rotation there will be a proper distribution of the reindeer-moss stands that are being restored. This makes it possible to have on each section of the pasture-rotation or turn-over the required reserve of fodders at the time when it is to be utilized.

When introducing pasture-rotation, for practical consideration one must take into account a whole series of local natural and economical peculiarities. Depending on the condition and the distribution of the fodder reserves, on the depth, compactness and distribution of the snow-blanket, on the size of the herd and other conditions one can accept or adopt a two-three and a four-year pasture-rotation. In connection with this the territory of the pastures is divided into two, three or four pasture-rotation sections, which correspond in capacity to the projected number of head and the dates for grazing and the order or sequence of the utilization of the individual sections is established. For instance, in the event of a three-or four-year pasture-rotation the individual sections can be used in a year's time

and then allow them to rest for four or six years. Similar digressions from the regular visits to the section of the pasture-rotation, over equal periods or intervals of time, are possible and do not contradict the basic demand of pasture-rotation, namely, that the entire area that is covered with reindeer-moss be utilized uniformly only once during the period for a complete restoration of the reindeer moss (several times depending on how crowded the grazing was).

Our task does not encompass the "concretization" of the pasture-rotations for the various natural and economical conditions. It was enough to show that a proper pasture-rotation is one of the necessary and basic prerequisites for regulating the increment-rate of the fruticose lichens.

Together with pasture-rotation an efficient exchange of pastures during a season should be organized. The latter, meeting at the same time the zoohygienic requirements, must provide for such an order or sequence in the utilization of the various types of winter pastures, which would make it possible to encompass more completely the forage reserves and, if possible, to keep the pastures that are rich in forage reserves for the period at the end of winter when it is more difficult to get feed.

The study of the accessibility of the various types of reindeer-moss pastures during the winter season, which we conducted in the Pechora forest-tundra (from 1940 to 1946), it was confirmed by the experience of the herders, shows that, first of all, at the beginning of winter, those pastures are used, which are the first to become inaccessible due to deep and packed snow.

To these types of pastures belong the fir or spruce thinned out forests and the sparse forests where the participation of the fir trees is not less than 50%, which are located in the subzone of the tundra sparse forests, in the immediate proximity of the treeless spaces or stretches (Pictures 9-10). As a result of the first considerable snowfalls, as early as the

latter part of December, the early part of January the snow lies to a depth of more than 50 cm in spruce forests and in sparse forests.

Picture 9. Sparse spruce forest in the MALOZEMELSKAYA forest-tundra, a heavy snow-blanket, that had failed to melt by the end of June (the photograph was made on June 20, 1951).

Picture 10. Sparse spruce (fir) forests along the northern line of the forest-tundra (the SED'IKHA river, the MALOZEMELSKAYA tundra). In the presence of a number of treeless pastures, where the snow is not as deep, it is difficult to compel the reindeer to dig for feed in the sparse forests. If the forage reserves in the spruce stands are not utilized until the snow is 50-60 cm in depth then, in view of more accessible pastures, they remain unused for the entire duration of the winter.

The next types that should be excluded from the "fund" of accessible pastures are the sparse forests of birch (of Betula tortuosa) and larch that occur on the treeless tundra or marshy stretches. The small islands of these sparse forests from snow retaining sections into which the snow is driven from the treeless stretches, which, at times, forms drifts of 2-3 meters in depth on the edge of the forests. Inside the sparse forests the snow is also considerably deeper than on the surrounding tundra and reaches a depth of 1 m in January-February.

Picture 11. Pasturing reindeer in a pine-lichen forest; the snow is loose or soft, about 70 cm deep.

Of the wooded types the thinned out forests of pine and larch, which form large massives along the northern rim of the taiga zone and belong partly to the subzone of the tundra sparse forests remain accessible longer than any other. Here towards the end of April the snow is 50-70 cm. The snow is usually loose or soft, its compactness does not exceed 0.5 (pictures 11 and 12).

In March-April the utilization of the wooded pastures is greatly curtailed and the herders in the forest-tundra, taking advantage of the fact that the time of the severe frosts and of the blizzards is over, drive the herds on to the open tundra sections, which consist mostly of the formations of lichen birch stand tundras. On these places, which are called "PLESHKI" (bald spots. Tr.) by the local population the snow, towards spring, reaches a depth of 35-40 cm and, if there are no crusts of frozen snow, can be dug up easily by the reindeer (picture 13).

Picture 12. Reindeer feeding upon the pine-lichen sparse forests in the latter part of winter. The reindeer feed not only upon the lichens on the ground but also upon the tree-lichens (epiphytes).

Picture 13. Reindeer grazing in April on sections of the lichen-birch stand tundras among the sparse forests.

During this time of the winter the sections of the lichen-birch stand tundras in the lower spots along the beds of creeks and brooks within the taiga zone acquire great significance. Here they are used primarily for moving the herds from the remote taiga winter pastures to the calving grounds in the forest-tundra. The direction or course of the main reindeer routes in winter in the taiga region is determined by the location of similar sections.

In the subzone of the southern tundra the sections of the lichen-birch stand formation the snow is much more packed in comparison with the region of the sparse forests and of the taiga. Here they usually feed only till February-March.

Picture 14. Grazing of reindeer on a tussocky tundra with lichens during the calving period (May).

Towards the end of winter the brush-less lichen and lichen-brush tundras and the peat-knolls covered with reindeer-moss are more accessible than any others. Because of this these places are especially valuable as pastures and must be reserved for this period.

D.I. GLINKA presents a similar picture of the seasonal change of winter pastures.

The organization of a "rational" seasonal change or exchange of winter pastures, bearing in mind the changing conditions of the accessibility of the pastures under the "concrete" conditions of each area, makes it possible first of all, to pasture or graze the entire area covered by reindeer moss to the fullest extent and, secondly, to reduce considerably the difficulties in obtaining feed at the end of winter; for these difficulties lead to an excessive consumption of the feeds in the dug-up places.

Thus the organization of a rational seasonal exchange of the winter pastures as well as the pasture-rotation is a necessary condition for regulating the increment-rate of the fruticose lichens.

These two measures are interrelated. When introducing pasture-rotation one must consider the demands of the seasonal exchange of pastures and set aside the sections of the pasture-rotation in such a manner as to make it possible to organize, within the scope of each of them, for the entire winter season a proper exchange of certain types of pastures. Each section of the pasture-rotation scheme should with regard to the reserves, condition and accessibility of the fodders meet the demands, which change during the winter, of reindeer-breeding. A lack or an insufficient area of pastures that are suitable, for instance, for the latter part of winter will necessarily necessitate the moving of a herd from this section in the latter part of winter to other, more suitable grazing grounds. This invalidates the proposed pasture-rotation. Before introducing a pasture-rotation scheme and setting aside the pasture-rotation sections it is necessary to study thoroughly the accessibility-conditions and to consider the experience of the leading brigades of herders regarding the utilization of the

various types of pastures. Unfortunately the reindeer breeding experts do not yet apply the principle in a satisfactory manner.

When dividing the pasture area into sections for pasture-rotation it is necessary to set aside reserve (STRAKHOVYE - insurance) sections in case of calamities (sleet, frozen snow-crust, deep snow drifts), due to which the pastures of the successive section of the pasture-rotation cannot be utilized. The reserve sections should constitute not less than 20-25% of the entire reindeer-moss area allotted to reindeer breeding.

The utilization of the sections of the pasture-rotation scheme should be in keeping with the established duration of the rotation, ~~exeryxfourkhxyearx~~ i.e. in the event of a two-year rotation each section is used within a year, in the event of a three-year rotation, every third, when a four-year rotation, every fourth year. However, it is possible to digress from this order due to the temporary inaccessibility of the pastures or economic reasons. It is possible to make use of the pastures for two years in succession, in isolated cases, three years, but after that the pastures must be allowed to rest for a long time. When one is compelled to violate the periodic dates for the utilization of pastures it must be borne in mind that one and the same section cannot be utilized more than twice every 4 years in the event of a two-year rotation, not more than three times every nine years in the event of three-year rotation and not more than 4 times every 12 years in the event of a 4-year rotation. In view of the change during the winter in the feed-getting conditions and the exchange of the types of pastures during a season it will be advisable in a number of cases to apply different pasture-rotation schemes in the early part, in the middle and in the latter part of winter.

However, prior to studying this question one should pause briefly at the third necessary condition for the ~~practical~~ practical regulation of the increment-rate of reindeer-moss - the organization and the methods for pasturing reindeer. At

was stated above that by a proper adjustment of the size of a herd and the proper grazing methods it is possible, to a considerable extent, to change crowded feeding or grazing and the extent to which the fodders in the "LUNKI" (holes. Tr.) have been consumed.

In order to accelerate the increment-rate of the fruticose lichens one should strive for a superficial cropping of the lichens at a height of about 1/3 of the living part of a bush. This results in a sprouting of the forage mass -twice as fast- which accelerates the date of the change-over in the pasture and increases their capacity considerably.

Late in fall and early in winter on the slight snow cover the reindeer-moss is usually cropped by the reindeer on a considerable area up to 40-50%, but only superficially. The job at this time is the timely transfer of herd from the used sections to fresh or new pastures. Delaying a herd results in a more complete consumption of the reindeer moss, which, if a considerable area, covered by reindeer moss, has been pastured, reacts unfavorably upon the further restoration of the forage reserves. The experience of the reindeer-breeders shows that in a number of cases, as a result of a long stay of herds, the late-fall reindeer-moss pastures are greatly exhausted and need a prolonged rest to restore the forage reserves.

In the middle of winter, in order to maintain the superficial cropping of the reindeer-moss, it is necessary to organize less crowded grazing by using 25-30% of the reindeer-moss reserves and by a timely transfer of the reindeer to new pastures. Picture 15. Supplying the reindeer with table salt (beginning of June, Malozemelskaya tundra).

In the latter part of winter one usually fails in trying to "organize" a superficial cropping. The task at this time is reduced to the fact not to tolerate a rather close cropping of the reindeer-moss from by limiting the use of the reindeer-moss from the "LUNKI" (holes) to 70-80% of the total reserves.

In order to reach this goal : herd should be moved in the latter part of winter to pastures with less snow and a large reserve of reindeer-moss, the activity of the reindeer with regard to digging up the snow, should be maintained by a systematic feeding of salt (picture 15), the weak reindeer should be removed from the general herds and be put into special convalescent groups.

The enumerated demands upon the pasturing of reindeer should be met simultaneously with the establishing of a pasture-rotation system and a proper order in the exchange of pastures within a season. These three groups of measures are bound together inseparably. Their implementation should be carried out on the basis of a detailed study of the natural and economic conditions of the locality.

One can adduce the following approximate scheme or chart of the dependence of the pasture-rotation upon the dates of the restoration of the reindeer moss, the density of grazing (area of the cropping of the reindeer moss in % of the general area of the "TROPA") and the extent to which the fodders in the "LUNKI" (holes) have been consumed.

Table 27.

Duration of the pasture-rotation period in dependence upon the dates of the restoration of the forage reserves.

1 - Species of Cladonia and the mean duration of the increment-accumulation period (in years). 2 - Nature of the cropping of the reindeer-moss. 3 - Area of the cropped forage in %.

a - medium -- 3 years, 4 years.

b - superficial -- 2 years, 2 years.

c - medium -- 2 years, 3 years, 4 years.

d - superficial ----------2 years.

This chart shows that in the event of a medium or average cropping of the lichens the pasture-rotation on "late ripening" reindeer-moss stands, depending on the area of the cropped forage, must be of three or four years (an area of a consumption of 40-50% should not be tolerated in this case), on the "middle or medium" and the "early-ripening" reindeer-moss stands, it should be a two-three or four-year rotation. In the event of a superficial cropping of the lichens, a two-year pasture-rotation is sufficient.

It was stated above that the size of a herd has a great effect upon the nature of the utilization of the forage. The duration of the pasture-rotation depends, to a certain extent, upon the size of a herd. Some researchers drew attention to this aspect. V.N. VASILYEV, on the basis of information received from reindeer-keepers in the AMGUYR region, wrote that in the case of small herds it is possible to use the reindeer-moss stands every year, but that in the case of large herds a three-four year pasture-rotation is required (1936, p. 97). The size of the herd was not disclosed by him. Proceeding from the experience in the study of the methods for the use of pastures in the reindeer-breeding industry in the YAMALO-NENETSK and NENETSKI national districts, one should come to the conclusion that in the case of a herd from 250-300 head the reindeer mosses are cropped superficially and not more than 15-20% of the reindeer-moss covered area are used for pasturing. This makes it possible to use the pasture every year. However, the use of one and the same sections every year does not safeguard or ensure uniformity in the use of the reindeer-moss on the entire area of the pastures. As a result their capacity is reduced. Furthermore, it must be borne in mind that rather small herds are of no economical advantage to the large reindeer-breeding kolkhozes and sovkhozes; for they would require a larger number of herders. When a herd is small the labor output is reduced the earning capacity of the reindeer breeding industry is reduced.

The experience or practice of the leading reindeer-breeding farms show that 1200-1500 head constitute a proper herd in the forest-tundra and in the tundra.

Depending on the size and the accessibility of the forage areas a division of a herd into two parts can be tolerated temporarily. A herd of 1200-1500 head makes it possible to regulate the increment or growth-increase of the reindeer-moss.

By means of pasture-rotation, by a proper seasonal exchange of pastures and the proper pasturing methods a uniform utilization of the forage area can be achieved and, as much as possible, ensure a superficial cropping of the reindeer-moss for the most part of the winter season. If a herd is increased beyond the size indicated above then the necessary efficiency in controlling the movement of a herd on a pasture is not safeguarded and the increment of the reindeer moss is reduced due to a more complete and concentrated consumption of it.

The capacity of a pasture, in the event of a superficial cropping of the reindeer moss is considerably increased as a result of the acceleration of the increment of the reindeer-moss. This makes it possible to obtain systematically a large amount of forage. For instance, on the "late-ripening" reindeer-moss stands, if the reindeer moss is cropped at 2/3 - 3/4 of its height, the annual "allowance" of reindeer-moss can be within 4-7% of the total reserves. If the reindeer moss is cropped superficially, 8-11%. The corresponding values on "early-ripening" reindeer-moss stands comprise 6-10% and 8-13% of the total amount or reserves of the "ripe" reindeer moss.

The following coefficients may be suggested for a practical determination of the bulk of the annual increment of the reindeer-moss. The latter are applicable in those cases where the reindeer moss is restored to its normal height.

Table 24.

The bulk of the annual increment of reindeer-moss at various heights of cropping in various species of Cladonia with a varying age of the podetia.

1 - Height of cropping. 2 - Bulk of the annual increment in % of the total reserves of reindeer-moss.
Cladonia sylvatica. a - 7-9 years; b-10-13 years; c - 13-15 years.
Cladonia alpestris: a - 11-13 years; b - 14-16 years; c - 17-19 years
A. Low cropping (at 9/10). B. Medium (at 2/3-3/4). C. Superficial (at 1/3).

If the reindeer moss is not given time to recover to the normal height and is used systematically while still of a low height then its increment-bulk will be different. In order to determine it other or different coefficients are required depending on the usual height of the reindeer-moss that is being utilized.

Table 28 shows that in the event of a superficial cropping of the reindeer-moss the annual "allowance" of the forage reserve is increased about 1½ times in comparison with a cropping at 2/3 - 3/4 of the height and two times in comparison with low cropping.

Superficial cropping makes it possible to establish shorter pasture-rotations by means of which larger pasture areas are utilized annually or every year. This aids in making greater use of the reserves of the green grasses under the snow. In the event of a four-year pasture-rotation the green grasses under the snow are utilized only on 1/4 part of the pasture area, in the event of a three-year pasture-rotation on 1/3 of the pasture-area and in the event of a two-year pasture-rotation on ½ of the pasture area.

The acceleration of the increment or growth of the reindeer-moss and the utilization of a larger reserve of green fodders under the snow increases considerably the capacity of the pastures.

When reindeer breeding is on a sufficiently high level one should in a number of kolkhozes and sovkhozes, depending on the natural and economic conditions, apply various pasture-rotations at various periods in winter. In the beginning and, if possible, in the middle of winter one should strive to implement a two-year pasture-rotation. In the latter part of winter a three or four-year pasture-rotation is more advisable. This will lead to

a fuller utilization of the natural resources.

2. On the possibility of accelerating the increment of lichens by applying special measures.

At the moment the questions of the stimulation of the increment or growth of lichens by special measures are not yet answered, seeing that the biology of the growth of the lichens has not been studied thoroughly. It should be borne in mind that the measures to stimulate the growth of the lichens could be of two kinds. Some directed at lengthening the period of the increment-accumulation, the others, at accelerating the annual growth-increase. In the event of the lengthening of the period of the increment-accumulation an increase of the general reserve of the fodder bulk and, on the average, an acceleration of its increment will be achieved; for during each successive year in the life of a podetium, which is in the first period of its development, the size of the increment increase. The lengthening of the period of the increment-accumulation even for one year can produce a tangible effect. For instance, the average increment of the mass during the first period in the life of the podetium of Cladonia sylvatica comprises, in the mean, if the period lasts for nine years, 2.6 centners per ha, if it is ten years - almost 3.0c/ha (centner per ha) and the forage reserve in the first case amounts to 23.5 c/ha, in the second case, almost 30 c/ha.

The acceleration of the annual increase, it seems, is the more difficult way; but we have no reasons to refuse to try it.

Experiments, in a ~~practical~~ practical sense, with regard to accelerating the increment of the fruticose lichens were conducted at several experimental stations of the Scientific Research Institute for Arctic Agriculture, Animal Husbandry and Hunting, V... KOV.KIN..., a geobotanist, has carried out these experiments, since 1943, on the largest scale at the Murmansk reindeer-breeding station.

The effect of two growth-promoting substances, heteroauxin and dichlorphenoxy butyric acid, was tested on a reindeer-moss cover cut down to one half. The influence of the growth-promoting substances upon the acceleration of the increment and the sprouting of the podetia is not yet recorded.

The application of common wood ashes produced rather negative results. Ashes to the amount of 500 g per 1 m^2 were applied on top of the sod and under the sod. In the first case, a year later, the lichens perished completely, in the second case they began to die off.

Some increment acceleration is achieved by shading (see above, p. 47). However, it is still too early to discuss its value as a measure in agricultural engineering.

However, the lack of practical results so far must not bring further search to a standstill. A number of other effects must also be tried. The fact that the lichens react sharply to some influences, is attested by the observations of B.N. GORODKOV, which he kindly reported to us, regarding the luxuriant growth of the crustose and foliose lichens on bird rookeries in the Arctic. This, he assumes, is in connection with the enrichment of the substratum with nitrous compounds.

Further research must be based on a thorough study of the biological processes of the development of the fruticose lichens. Only in this case can it be expected that the methods for accelerating the increment of the lichens by regulating the dates or intervals and the height at which they are cropped will be undergirded by special agricultural-engineering methods.

Conclusions.

1. The growth of the fruticose lichens of various species and under various conditions takes place at a various rate. The amount of the increment, furthermore, passes through considerable changes during the process of ontogenesis and depends also upon the development-period of the plant and upon the size and age of the living part of the fruticose thallus.

2. In the fruticose species of the Cladonias the stem of the podetium branches only once a year in the upper part. Every year there appears on the stem of the podetium one joint by which is meant the distance between t e main lateral branches. The joints during the first year of their appearance are represented by small "ROZHKI" (horns. Tr.) about 0.5 mm in length. In the years that follow the joints increase their length considerably. The growth-period of every joint, in the mean, continues for about 10 years, with fluctuations from 6-7 to 20-25 years. During the first half of this period the value or amount of the increment of the joint increases gradually every year, during the second half, it drops sharply. During this time the size of each joint increases 10-15 times in comparison with the original length. The cessation of growth in the joint is related to the death of the cells of the algae; at the same time the fungous component begins to die off.

3. The growth of the podetium, as a whole consists of the increment of the individual joints. There are three periods in the life of a podetium. The first is the period of the formation of the podetium or of the accumulation of increment, the second is the period of the dying of the podetium.

During the first period the length of the podetium increases annually at the cost of the appearance of new joints and the extension of all the joints that compose it. The size of the increment during this period with increases every year, seeing that every year the number of the growing joints increases.

During the second period the total length of the podetium continues to grow, but the length of the living part remains more or less the same in view of the fact that in the base of the podetium there occurs every year the death of one joint. The growth of the podetium is continued during this period, but there is no further increment-accumulation in view of the constant number of joints in the living part of the podetium. At the beginning of the second period due to the growth of the lateral branches the accumulation of the living mass continues for some time. During this

period the living part of the podetium attains the greatest length and has the largest number of joints. The number of the joints in the living part of the podetium corresponds to their life-span.

During the third period there occurs a curtailment or contraction of the living part of the podetium and its gradual dying off due to the reduction in the vitality of the plants, which becomes manifest in the dying-down of the ramifying process and in the reduction of the life-span of the individual joints.

Under certain living conditions, in every species of fruticose lichens, the duration of the first period of existence is characterized by a magnitude, which is more or less definite. The second period of existence can continue for many decades not less than one hundred years. Seeing that the external conditions can change during such a long time it is difficult to speak about a definite length of this period.

A change in the nutrition regime greatly affects the size of the plant and the life-span of the individual joints. The length of the living part of the podetium and the number of the joints in it increases with improved living conditions and decreases when the living conditions deteriorate. The growth-rate depends to a considerable degree upon the length of the living part of the podetium, which determines the size of the assimilating surface and the magnitude of the metabolism. The self-regulating of the length of the living part of the podetium is of essential significance in adapting the fruticose lichens to the severe living conditions and, together with the great resistance of the lichens to frost and drought, facilitates their wide-spread occurrence in the Far North and on high lands.

5. The sprouting of the podetium of Cladonias as well as also of the fruticose thallus in other lichens after a removal of its larger or smaller part by browsing reindeer is similar to the growth of the podetium during the first period of existence. On the "stump", that remained after the browsing there is being

formed, as it were, a new podetium the growth-rate of which depends upon the size of the "stump" that remained. If the young lateral branches remained intact then one of them will assume the function of the main stem of the podetium. In connection with this the sprouting-rate depends upon the length and age of the lateral branch. Usually when only the top of the podetium, within 1/4 - 1/3 of its height, is removed, the restoration continues for 2 - 5 years; when the larger part of the podetium, up to 2/3 - 3/4 of its height, is removed the restoration is continued for a period of time that is equal to the duration of the first period of the existence of the podetium, i.e. in the mean, about 10 years (with fluctuations from 6 - 7 to 20 - 25 years); if the entire or almost the entire living part of the podetium is removed the remaining dying base either dies completely or begins to sprout slowly. In this connection, the time of restoration is extended by 3 - 5 years.

b. For productive purposes it is important to establish the duration of the period of the increment-accumulation in the separate species of lichens under different conditions and the reserve of the living mass, that is created by the fully "ripened" reindeer-moss, i.e. which has fully completed the increment-accumulation period. The first value for the fruticose Cladonias can be established easily by counting the number of joints in the living part of the podetium, which is in the second period of existence. The reserve is determined by the usual method of making cuts on the "ripened" reindeer-moss stands or by means of special tables established on the basis of data on cuts.

The rate of the annual linear increment, in the mean, for the first period of the existence as well as also the growth rate for the second period and also the duration of the first period of the existence of the podetium and the height of the ripe or mature podetium can be determined by a morphological analysis of the samples of the podetium under chamber-conditions (?). The rate of the current increment for a year or for any period of time can be

determined only by special experiments in the open by the "mark"-method.

7. On the basis of a morphological analysis of 37500 samples of the podetia of Cladonia and the setting up of tests by the "mark"-method with more than 2000 samples of various species of the fruticose lichens in various areas of the Far North a number of regularities was established.

Firstly, the growth-rate, the height of the living part of the podetium and the duration of the increment-accumulation period differ considerably in regard to some species of lichens. Three groups can be set aside with regard to the "early ripening" of the lichens. "Late-ripening", the first period of existence is from 12-14 years (Cladonia alpestris), "medium-ripening", with a first period of9-11 years (Cl. sylvatica) and "early-ripening with a first period of 6-9 years (Cl. rangiferina). At the same time these groups differ with regard to growth-rate, which increases with an increasing early ripening. According to this distinguishing feature to the first group, with regard to the growth-rate (with the slowest rate), should belong Cetraria islandica; to the second, Cl. gracilis; STEREOCAULON; to the third, Cetraria cucullata and C. nivalis. The largest reserve of the living mass is accumulated by the slow-growing species, but they differ by their later ripening, the smallest reserve is formed by the rapidly growing, the early-ripening Cladonias. The growth-rate and the early ripening are

the important, in the economic sense, features and are of great importance for establishing the rôle of the separate species in composing vegetative communities.

Secondly, the growth-rate of all species depends upon climatic factors. Beginning with the northern sub-zones of the forest zone the growth-rate decreases northward and reacts immediately to any changes in the climate in the various subzones. Under one and the same zonal conditions the increment increases in localities with a more humid and a long summer.

Thirdly, the growth-rate of the lichens depends to a considerable extent upon the nature of the vegetation. Under more favorable micro-climatic conditions, created by an arboreal and brush vegetation the growth-rate increases sharply. In lichen-covers composed of one species the growth-rate, so it seems, is higher than in mixed covers.

The recorded peculiarities in the growth-rate and the duration of the increment-accumulation period of the fruticose lichens are essential in designing measures for their regulation.

5. The magnitude of the increment of the forage lichens can be changed by man to a considerable extent. The untimely and haphazard use of the pastures can greatly delay the increment and reduce the reserves of reindeer moss. By organizing the grazing of the reindeer according to a system it is possible to accelerate the growth-rate and to increase the accumulation of the reserve of the living mass of reindeer moss. For this purpose, it is necessary, first of all, to use the reindeer moss immediately after the completion of the increment-accumulation period, at the very beginning of the renewal-period of the podetium; for the utilization of "unripe" reindeer moss reduces the restoration-rate of the forage mass, seeing that the highest growth-rate is reached during the last years of the "ripening" and the utilization of over-ripe reindeer moss leads to a partial loss of the forage reserve due to the dying of the bases of the bushes; secondly, the cropping of the reindeer moss, in the main, must be superficial, i.e. it must be restricted to the top or tip of the bush which would be about 1/3 of the height of its living part; for under this condition the growth-rate of the reindeer moss is increased 1½ times in comparison with the increment, when the reindeer-moss is cropped at 2/3-3/4 of its height and two times in comparison with the increment when 80-95% of the living part of the bush are removed.

9. Pasture-rotation, which is an alternation of the pastures and a consideration for the time required for a restoration after the utilization of the forage reserves is the most important practical measure for regulating the increment of the forage lichens. The pasture rotation-period (duration of one rotation) depends upon the time required for the restoration of the forage reserves and the area of the pastures that have been pastured. The time needed for a restoration depends upon the duration of the increment-accumulation period and the height at which the reindeer moss was cropped. The area of the utilization of the pastures depends upon the degree of accessibility (depth and compactness of the snow blanket) of the pastures and the grazing methods. Recommended pasture-rotations: a two-year, when the reindeer mosses are cropped superficially; a three-year, when the reindeer-moss is cropped at 2/3-3/4 of its height and when the reindeer-moss covered surface of pastures is used to the extent of 15-20% in the case of "late ripening" reindeer-mosses and to 25-30% on "medium" and "early-ripening" reindeer-mosses; a four-year, when the reindeer moss is cropped at the same height and the reindeer-moss covered surface of pastures has been used to 25-30% on "lateripening" reindeer-mosses and to 40-50% on "medium" and "early ripening" reindeer-mosses. In most cases a two-year pasture-rotation is tolerable in the first half of winter and during the second half it is a three or four year rotation. In each case a study of the condition of the pastures must precede the establishment of the pasture-rotation. The natural and economical conditions that affect the pasture-rotation must also be studied.

10. Alongside with pasture-rotation of importance, for regulatin the increment of the fruticose lichens, is the organization of a proper- within the season -alternation of the pastures and the application of the proper methods in pasturing reindeer. The fullest utilization of the reindeer-moss reserves is achieved by a proper selection of the late-fall, winter and early spring

pastures and a properly organized alternation of them within the season. The sequence or order in which the pastures are used must see to it that the pastures that quickly become inaccessible because of the snow-blanket are "visited" first of all. The pastures that remain accessible longer than any other and have the most abundant forage reserves must be conserved for later on. A herd of 1200-1500 head, as is shown by the experience of the leading farms, is the proper size for the tundra and the forest-tundra. In the event of encountering difficulties in reaching the pastures or when the feeding area is broken up into small sections the herd should be divided temporarily into two parts. When a herd is of the proper size and the crowding or density of the reindeer is restricted to a certain limit, while grazing, and the reindeer are moved in time from a used pasture to a new or free place one can achieve a superficial cropping of the reindeer-moss for a considerable part of the time, when snow covers the ground, and prevent an excessive consumption of the reindeer moss, where the snow is dug up.

As a result of the implementation of the enumerated measures the increment of the reindeer moss increases, in some cases, almost two fold. This makes it possible to increase "the load" on the pastures accordingly.

11. The theory, developed in this work, of the increment of the fruticose lichens must be further developed. The imminent task is a thorough study of the biology of the growth of the fruticose lichens and to develop upon it special methods for stimulating the increment of the reindeer-moss, which would accelerate the increment to a considerably greater extent, than can be achieved at present by proper intervals and pasturing methods.

Note: Literature will be translated upon request.